



Faculty of Economics and Business

**Constructing Digital Economy Performance Indicators for ASEAN
Countries**

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Constructing Digital Economy Performance Indicators for ASEAN Countries

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Digital revolution has dramatically changed the world. Today, ASEAN is a key global economy but yet to be a key digital economy. As recognising digital integration lays the foundation of digital economic innovation and growth, ASEAN quickly adapts to change by targeting ‘single digital market’ as the regional market plan and secures massive opportunity to leapfrog in the vanguard. Digital integration is imperative but digital divide among member countries could be a hurdle to promote the region as a global hub of technological progress and growth. This study aims to assess the digital economy performance of ASEAN Member States (AMS) through the construction of a comprehensive Digital Economy Performance Indicator (DEPI). Specifically, the study has three main objectives: (1) to evaluate the performance of AMS across five critical dimensions—connectivity, infrastructure, affordability, human capital, and digital technology integration; (2) to aggregate these dimensions into a composite index using the entropy weighting method to ensure objectivity; and (3) to compare the digital economy performance of AMS for the period 2017–2021 to identify strengths, weaknesses, and developmental gaps. The entropy weighting method is chosen as the estimation strategy to derive unbiased weights for the indicators based on data variability. The weighted score of all dimensions is then aggregated into a final index score annually that wholly represents the digitalisation performance of each member country. The findings show that Singapore tops in all dimensional performance across years. From intra-country perspective, the analysis provides useful insights for all individual member country to identify the level of performance across dimensions with the calculated final scores. Meanwhile, inter-country analysis enhances economic convergence and reduces development gap within the region. The study will be of great assistance to propel ASEAN towards a digitally-enabled economy that is secure, sustainable and

transformative, and to further leverage digital technology to enable an innovative, inclusive and integrated ASEAN as in ASEAN Economic Community 2025 vision.

Keywords: Digital economy performance indicator, ASEAN, digital economy, indicator

Membina Petunjuk Prestasi Ekonomi Digital untuk Negara ASEAN

ABSTRAK

Revolusi digital telah mengubah dunia secara dramatik. Hari ini, ASEAN ialah ekonomi global yang penting tetapi masih belum menjadi ekonomi digital utama. Menyedari integrasi digital meletakkan asas inovasi dan pertumbuhan ekonomi digital, ASEAN cepat menyesuaikan diri dengan perubahan semasa dengan menyasarkan 'pasaran digital tunggal' sebagai pelan pasaran serantau dan menjamin peluang besar untuk melompat di barisan hadapan. Penyepaduan digital adalah penting tetapi jurang digital antara negara anggota boleh menjadi halangan untuk mempromosikan rantau ini sebagai hab kemajuan dan pertumbuhan teknologi global. Kajian ini bertujuan untuk menilai prestasi ekonomi digital Negara-Negara Anggota ASEAN (AMS) melalui pembinaan Petunjuk Prestasi Ekonomi Digital (DEPI) yang komprehensif. Secara khusus, kajian ini mempunyai tiga objektif utama: (1) menilai prestasi AMS merentas lima dimensi kritikal—ketersambungan, infrastruktur, kemampuan, modal insan, dan integrasi teknologi digital; (2) menggabungkan dimensi-dimensi ini menjadi satu indeks komposit menggunakan kaedah pemberat entropi untuk memastikan objektiviti; dan (3) membandingkan prestasi ekonomi digital AMS untuk tempoh 2017–2021 bagi mengenal pasti kekuatan, kelemahan, dan jurang pembangunan. Kaedah pemberat entropi dipilih sebagai strategi penganggaran untuk mendapatkan pemberat yang tidak berat sebelah bagi petunjuk berdasarkan kebolehubahan data. Skor wajaran semua dimensi kemudiannya diagregatkan ke dalam skor indeks akhir setiap tahun yang mewakili sepenuhnya prestasi pendigitalan setiap negara anggota. Penemuan menunjukkan bahawa Singapura mendahului dalam semua prestasi dimensi sepanjang tahun. Dari perspektif dalam negara, analisis memberikan cerapan berguna untuk semua negara anggota individu untuk mengenal pasti tahap prestasi merentas dimensi dengan skor

akhir yang dikira. Sementara itu, analisis antara negara meningkatkan penumpuan ekonomi dan mengurangkan jurang pembangunan di rantau ini. Kajian itu akan menjadi bantuan besar untuk memacu ASEAN ke arah ekonomi yang didayakan secara digital yang selamat, mampan dan transformatif, dan untuk terus memanfaatkan teknologi digital untuk membolehkan ASEAN yang inovatif, inklusif dan bersepadu seperti dalam wawasan Komuniti Ekonomi ASEAN 2025.

Kata kunci: *Penunjuk prestasi ekonomi digital, ASEAN, ekonomi digital, penunjuk*

TABLE OF CONTENTS

	Page
DECLARATION	i
ACKNOWLEDGEMENT	ii
ABSTRACT	iii
<i>ABSTRAK</i>	v
TABLE OF CONTENTS	vii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS	xv
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Background of the Study	5
1.2.1 ASEAN Digital Economy Outlook	6
1.2.2 Overview of AMS Rank in Various Digital Indexes	15
1.3 Problem Statement	19
1.4 Research Question	21
1.5 Objectives of the Study	22
1.6 Significance of the Study	22

1.6.1	Novelty	24
1.6.2	Potential Applications	25
1.6.3	Impact on Social, Economy and Nation	25
1.7	Scope of the Study	25
CHAPTER 2 LITERATURE REVIEW		27
2.1	Introduction	27
2.2	Theoretical Review	27
2.2.1	Technology Acceptance Model (TAM) (Davis, 1989)	27
2.2.2	Innovation Diffusion Theory (Rogers, 1962)	29
2.2.3	Digital Divide Theory (Norris, 2001)	31
2.3	Digital Indices by Global Organisations in Recent Years	32
2.3.1	Digital Economy and Society Index by European Commission	32
2.3.2	International DESI by European Commission	35
2.3.3	Network Readiness Index by Portulans Institute	37
2.3.4	Digital Adoption Index by World Bank	42
2.3.5	ICT Development Index by ITU	44
2.3.6	Mobile Connectivity Index by GSMA	45
2.3.7	The Web Index by World Wide Web Foundation	47
2.3.8	Global Digital Readiness Index by Cisco	49
2.4	Review of Previous Studies	50

2.4.1	Global Efforts in Digital Economy Measurement	50
2.4.2	Regional Studies and Limitations	52
2.4.3	Digital Divide and Measurement Challenges	54
2.5	Gap in the Literature	55
CHAPTER 3 METHODOLOGY		60
3.1	Introduction	60
3.2	Flow of Constructing DEPI	60
3.3	Structure of DEPI	63
3.3.1	Dimension 1: Connectivity	64
3.3.2	Dimension 2: Infrastructure	64
3.3.3	Dimension 3: Affordability	65
3.3.4	Dimension 4: Human Capital	65
3.3.5	Dimension 5: Digital Integration of Technology	66
3.3.6	Rationale for Selection of Components	66
3.4	Similarity and Dissimilarity between DEPI and I-DESI	73
3.5	Methodological Considerations	74
3.5.1	Selection Criteria	75
3.5.2	Data Updates	75
3.5.3	Data Treatment	76
3.5.4	Imputation of Missing Observation	78

3.5.5	Normalisation	78
3.5.6	Determining Weights of Different Variables based on Entropy	79
3.5.7	Aggregation	81
3.5.8	Rationale of Using Entropy Weight Method (EWM) as Weighting Approach	83
3.5.9	Classification	84
3.6	Robustness Checking	86
3.7	Chapter Remark	87
	CHAPTER 4 RESULTS AND DISCUSSIONS	88
4.1	Overview	88
4.2	Skewness and Kurtosis Results	88
4.3	Weightage Results of Entropy Evaluation	92
4.4	AMS DEPI Score across Years	95
4.5	Sensitivity Analysis	111
4.6	Country Findings	116
4.6.1	Brunei Darussalam	116
4.6.2	Cambodia	120
4.6.3	Indonesia	123
4.6.4	Lao	127
4.6.5	Myanmar	130
4.6.6	Malaysia	134

4.6.7	Philippines	138
4.6.8	Singapore	141
4.6.9	Thailand	145
4.6.10	Vietnam	150
4.7	Classification	154
4.8	Chapter Remark	156
CHAPTER 5 CONCLUSION AND RECOMMENDATIONS		160
5.1	Conclusion	160
5.2	Policy Recommendations	162
5.3	Challenges, Limitations, and Future Research of the Study	168
REFERENCES		169

LIST OF TABLES

	Page
Table 1.1: Internet Economy 2025 Projections for Selected AMS	8
Table 1.2: GCI 2020 Ranking in Asia-Pacific Region	11
Table 1.3: Ranking and Scores of AMS in Various Digital Indices	16
Table 2.1: Structure of the DESI 2022	34
Table 2.2: Structure of the I-DESI 2018	36
Table 2.3: Structure of NRI 2016	37
Table 2.4: Structure of the NRI 2019	40
Table 2.5: Structure of the DAI	43
Table 2.6: Structure of the IDI	44
Table 2.7: Structure of the MCI	46
Table 2.8: Structure of the Web Index	48
Table 2.9: Structure of GDRI	49
Table 3.1: DEPI Structure	70
Table 3.2: Similarities and Dissimilarities of Indicators between DEPI and I-DESI	73
Table 3.3: Value and Level of Development	84
Table 4.1: Descriptive Statistics	89
Table 4.2: Entropy Evaluation of Variables (Weightage)	92
Table 4.3: Entropy Evaluation of Variables (Weightage)	93
Table 4.4: Summary Changes of AMS Performance from 2017 to 2021	109
Table 4.5: Comparison of Results between Entropy and Equal Weight	113

LIST OF FIGURES

	Page
Figure 1.1: Focus Areas of Digital ASEAN Initiative	8
Figure 1.2: The Specific Commitments to be Achieved by 2020, ASEAN Digital Skills Vision 2020	9
Figure 1.3: Key Focus Areas for ASEAN Digital Economy	12
Figure 1.4: Individuals using the Internet in AMS, 2019-2021	13
Figure 1.5: Fixed Broadband Speed of AMS, March 2020	13
Figure 3.1: ADM 2025	62
Figure 3.2: Flow of Constructing DEPI	63
Figure 3.3: Process Flow of Evaluation Index System	83
Figure 4.1: AMS DEPI 2017	97
Figure 4.2: AMS DEPI 2018	98
Figure 4.3: AMS DEPI 2019	98
Figure 4.4: AMS DEPI 2020	99
Figure 4.5: AMS DEPI 2021	99
Figure 4.6: Visualisation of AMS DEPI 2017 in Heat Map	104
Figure 4.7: Visualisation of AMS DEPI 2018 in Heat Map	105
Figure 4.8: Visualisation of AMS DEPI 2019 in Heat Map	106
Figure 4.9: Visualisation of AMS DEPI 2020 in Heat Map	107
Figure 4.10: Visualisation of AMS DEPI 2021 in Heat Map	108
Figure 4.11: Ranking Comparison of AMS in terms of DEPI across Years	111
Figure 4.12: Dimensional Score of Brunei DEPI from 2017-2021	119
Figure 4.13: Dimensional Score of Cambodia DEPI from 2017-2021	123
Figure 4.14: Dimensional Score of Indonesia DEPI from 2017-2021	126

Figure 4.15: Dimensional Score of Laos DEPI from 2017-2021	130
Figure 4.16: Dimensional Score of Myanmar DEPI from 2017-2021	133
Figure 4.17: Dimensional Score of Malaysia DEPI from 2017-2021	137
Figure 4.18: Dimensional Score of Philippines DEPI from 2017-2021	141
Figure 4.19: Dimensional Score of Singapore DEPI from 2017-2021	145
Figure 4.20: Dimensional Score of Thailand DEPI from 2017-2021	150
Figure 4.21: Dimensional Score of Vietnam DEPI from 2017-2021	154
Figure 5.1: The Way Forward to Foster Digital Revolution in ASEAN	166

LIST OF ABBREVIATIONS

2G, 3G, 4G, 5G	Second/Third/Fourth/Fifth Generation
ADGMIN	ASEAN Digital Ministers' Meeting
ADII	ASEAN Digital Integration Index
ADIX	ASEAN Digital Index
ADM	ASEAN Digital Masterplan
AEC	ASEAN Economic Community
AI	Artificial Intelligence
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
COVID-19	Coronavirus Disease
DAI	Digital Adoption Index
DEPI	Digital Economy Performance Indicator
DESI	Digital Economy and Society Index
DKEI	Digital Knowledge Economy Index
EC	European Commission
EU	European Union
EWM	Entropy Weight Method
Fintech	Financial Technology
GB	Gigabyte
GCI	Global Cybersecurity Index
GDP	Gross Domestic Products
GDRI	Global Digital Readiness Index
GHz	Gigahertz

GITR	Global Information Technology Report
GNI	Gross National Income
GSMA	<i>Groupe Speciale</i> Mobile Association
ICT	Information and Communications Technology
I-DESI	International DESI
ID	Identification
IDI	ICT Development Index
IMD	International Institute for Management Development
IP	Internet Protocol
ITU	International Telecommunication Union
IXPs	Internet exchange points
LPI	Logistics Performance Index
MB	Megabyte
Mbps	Megabits per Second
MCI	Mobile Connectivity Index
MIGHT	Malaysian Industry-Government Group for High Technology
MPAC	Masterplan on ASEAN Connectivity
NRI	Networked Readiness Index
OECD	The Organization for Economic Cooperation and Development
PCT	Patent Cooperation Treaty
SEA	Southeast Asia
SME	Small and Medium Enterprise
SOM	Self-organizing Map
STEM	Science, Technology, Engineering and Mathematics
TLDs	Top-Level Domains

UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WC-PSS	Working Committee on Payment and Settlement Systems
WEF	World Economic Forum
WWW	World Wide Web

CHAPTER 1

INTRODUCTION

1.1 Introduction

The term "Digital Economy" was first introduced by Don Tapscott, who coined the term in his 1995 bestseller, "The Digital Economy: The Promise and Danger of the Age of Networked Intelligence". At that time, web browser was in beta version, no transaction can be performed through website, and used dial-up modems. Google, Paypal, Facebook, Youtube, and Twitter¹ did not even exist at that time. The widespread of Internet during globalisation and the introduction of smartphones since 2007 further foster economies into digital. It is evident that new information technology (IT) wave tremendously transforms business strategies, create and market products and services, and changes the way of netizen's lifestyle. It is not exaggerated to say that digital transformation rules the business success and people's lives, at all means especially now in the Fourth Industrial Revolution (IR 4.0).

Soon, the rapid evolution of ICTs drastically changed or altered the way of people communicate, handle or operate business, do trading and transactions, as well as their daily routines and life styles. Nowadays, people carry out a lot of activities using the Internet like sending emails, surfing the web, writing blogs, accessing social media, watching YouTube, reading digital news, shopping online and many more the e-mailing, web surfing, use internet service to do blogs, access to social media tools, view YouTube, read digital news, do some

¹ Date & Location of Founded: Google: September 4, 1998, Menlo Park, California, United States; Paypal: December 1998, Palo Alto, California, United States; Facebook: February 2004, Cambridge, Massachusetts, United States; Youtube: February 14, 2005, San Mateo, California, United States; Twitter: March 21, 2006, San Francisco, California, United States

online shopping and transaction, and many other online activities. Despite personal changes, today many countries have adopted the implementations of e-learning, e-business, e-banking, e-commerce, e-finance, e-tax and etc. All these are so-called the ‘digitalisation changes’ and it is where the concept of a ‘digital economy’ comes into picture.

Digital economy is also quite popular to be called as the Internet economy, the new economy, or web economy. It is a simple term but yet way too complex to be comprehensively explained by a synthetic and precise definition. It is undeniable that digitalisation has developed as the prominent driver of innovation and growth across the world. It is hard to find a single sector in businesses or any aspect in human life that has not been penetrated by the digital transformation, especially in the recent years. Such a fast growing of digital economy has prompted leaders to explore the digital potential and opportunity in Southeast Asia region. In relation to this, the ASEAN bloc in the region has a great opportunity to leapfrog into the vanguard in this digital era.

Different countries, organisations and unions in the world embrace digitalisation at its own pace and way. Among others, the World Economic Forum (WEF) quickly adapts to the digital change by introducing the Networked Readiness Index (NRI) in 2002 and providing an all-inclusive framework for gauging the multi-faceted impact of ICT on society and the development of countries. Also, Organisation for Economic Co-operation and Development (OECD) examines the digital evolutions, and rising opportunities and challenges in digital economy through publishing various reports such as “Digital Economy Outlook”, “Digital Economy Papers”, and creating framework on “Measuring the digital economy” with a comprehensive set of digital-relevant indicators for comparisons between countries. European Union in their strategy of creating a ‘Digital Single Market’ opens up a digital scoreboard called “Digital Economy and Society Index” that measures and compares

the digitalisation level among its member countries, which also enlightens the leading and lagging areas in their digitalised transition.

There is no clear boundary and criteria that digitalises an economy to be digital economy. According to Zhang and Chen (2019), as mentioned in their IMF Working paper, digital economy can simply refers to the ICT sectors only, from all range of ICT-related industries such as telecommunications, IT services, or even hardware and software. Whereas, in a broad term, digital economy involves not only the ICT sector but also integrates parts of traditional sectors with digital technology. The G20 uses this broad concept to define digital economy as a wide range of economic activities with digital information and knowledge as key production factor and modern information networks as an important activity space. However, instead of defining it with rigid standards, people are more concerned on how to embrace it and benefit from the transformation.

In terms of digital economy, developed countries are still dominating it with more than half of the share. According to Banga (2018), the digital economy contributed around 3.4 percent to gross domestic product (GDP) in developed countries, and that was three times higher than the digital economy could make for African countries. Particularly in ICT capital, the report by World Bank (2016) revealed that its contribution to GDP growth of developing countries was fair, with around 15 percent of growth. They claimed this percentage to be indicating low digital adoption in developing countries. But this value has great potential to rise in future with the current speedy diffusion and integration of digital technology in developing countries.

The concept of the digital economy refers to an economy that is based on digital technologies, including the internet, mobile technology, and other tools that enhance connectivity, data sharing, and automation. Over the past few decades, the digital economy

has emerged as a key driver of economic growth, contributing significantly to productivity, efficiency, and competitiveness across industries. For both developed and developing countries, the digital economy has transformed traditional business models, facilitated cross-border trade, and spurred innovation in various sectors such as e-commerce, financial services, and smart manufacturing.

In developed economies, such as the United States and European Union, the digital economy has fueled significant advancements in innovation, job creation, and value-added services. Meanwhile, in developing countries, it presents opportunities for economic inclusion, bridging geographic and socio-economic divides, and enabling access to markets, education, and financial resources. However, the extent of digital economy contributions varies considerably, particularly in regions with significant disparities in infrastructure, digital literacy, and institutional support.

The experiences of China and India highlight critical lessons for emerging economies in fostering digital transformation. While these two countries are not part of the ASEAN Member States (AMS) sample in this study, their rapid advancements offer insights into strategies for leveraging digital technologies to achieve economic growth. China's robust investment in digital infrastructure, innovation ecosystems, and e-commerce has positioned it as a global leader in the digital economy. Similarly, India's adoption of digital payments, e-governance, and initiatives like Digital India demonstrates the transformative potential of digitalization in addressing socio-economic challenges. These examples underscore the importance of tailored policy interventions and investments, which are equally relevant for ASEAN economies aiming to bridge their digital divides and unlock sustainable growth through digital transformation.

Following China Academy of Information and Communications Technology (CAICT), Ministry of Industry and Information Technology, China (2018) reported that the digital economy of China achieved 27.2 trillion yuan in 2017. International Data Corporation (IDC) even predicts its GDP to have around 51.3 percent with digitalisation-related by 2023. It is forecasted that by 2025, at least 80 percent of new enterprise applications in China will artificial intelligence technology. China is expected to continue its rapid digitization, with the digital economy accounting for even close to 50 percent of GDP by 2025 (Zhang and Chen, 2019).

From 2016-2017, the digital economy reached \$413 billion (15-16 percent) to India's GDP, according to joint report by Ministry of Electronics and Information Technology, Internet and Mobile Association of India (2018). India could create a digital economy worth \$800 billion to \$1 trillion by 2025 (worth 18-23 percent of the country's nominal GDP), according to Ministry of Electronics and Information Technology, India, in partnership with McKinsey (2019).

This chapter is organised as follows: Section 1.2 background of the study, Section 1.3 problem statement, Section 1.4 objectives of the study, Section 1.5 significance of the study, Section 1.6 scope of the study.

1.2 Background of the Study

This section elaborates particularly on the ASEAN digital economy outlook, digital divide among ASEAN Member States (hereinafter, AMS), key challenges arising from there, as well as pinpoint AMS's general performance in distinctive indexes that are of digital-relevance.

1.2.1 ASEAN Digital Economy Outlook

The digital industry has become a major driver of innovation and growth globally. In this digital revolution, digital technology has greatly changed the world. Today, ASEAN has become an important global economy, but it has not yet become an important digital economy. Recognizing that digital integration lays the foundation for innovation and growth in the digital economy, ASEAN adapts quickly to changes by targeting multiple regional market initiatives in order to secure massive opportunity and thus leapfrogs in the vanguard. A global management consulting firm, AT Kearney in conjunction with Axiata Group Berhad (one of the largest telecommunication companies in Asian) had attracted the eyes of the world in an annual mobile world congress in 2016, whereby they expected the growth of digital economy could add US\$1 trillion to the gross domestic product of the ASEAN bloc over the next ten years in their report titled ASEAN Digital Revolution, released on the year of 2015.

Obviously, not only the mobile industry anticipates the emerging potential of digital economy in Southeast Asia, Google Company and Temasek Holdings (a Singapore government-owned holding company) in their report “e-Conomy SEA Spotlight 2017” released on May 2016 also emphasized that Southeast Asia is experiencing remarkable growth in Internet usage, currently boasting a user base of 260 million, with projections indicating it will reach 480 million by 2020. Moreover, forecasts suggest that by 2025, Southeast Asia is poised to become one of the top five digital economies globally. Additionally, the concept of a unified digital market within ASEAN was proposed by Mr. Tharman Shanmugaratnam, the Deputy Prime Minister of Singapore, during a panel session held in Jakarta in March 2018, which was organized by Bank Indonesia and the International Monetary Fund.

The "Digital ASEAN" initiative is part of the broader strategy outlined in April 2018 by the World Economic Forum (WEF) called "Shaping the Future of Digital Economy and New Value Creation," aimed at aligning with the Fourth Industrial Revolution (IR 4.0). Its objective is to tackle the challenges that ASEAN member states (AMS) will encounter in becoming a regional digital economy. As stated by the World Economic Forum in 2019, ASEAN stands out as the fastest-growing Internet market globally, with approximately 125,000 new Internet users added each day. This makes the projections of ASEAN digital economy over the next ten years to grow remarkably and likely to hit around \$1 trillion to the region's GDP. Google, Temasek Holdings, and Bain & Company in their latest report of "e-Conomy SEA Spotlight 2019" highlighted that digital economy in Southeast Asia has soared to \$100 billion for the first time in 2019. This number was more than tripling in size over the last four years. Now they even predict that the digital economy in this region has a great potential to hit \$300 billion by 2025. In the report, it is also mentioned that the Internet users in Southeast Asia has escalated from 260 million (2015) people to 360 million people (2019), an increase of nearly 40 percent just in four years' time.

Table 1.1: Internet Economy 2025 Projections for Selected AMS

Country	Gross Merchandise Value (billion in US\$)	Compound Annual Growth Rate (from 2015-2025)
Indonesia	133	32%
Thailand	50	24%
Vietnam	43	29%
Singapore	27	15%
Malaysia	26	18%
Philippines	25	27%

Source: e-Conomy SEA Spotlight 2019 report by Google, Temasek Holdings, and Bain & Company

Nevertheless, recognising that there are obstacles in realizing those projections, ASEAN has come out with several policy frameworks in order to ease the way. The masterplan on ASEAN Connectivity (MPAC) 2025, AEC Blueprint 2025, e-ASEAN Framework Agreement and ASEAN Vision 2040 are amongst the policy measures to address the hindrances.

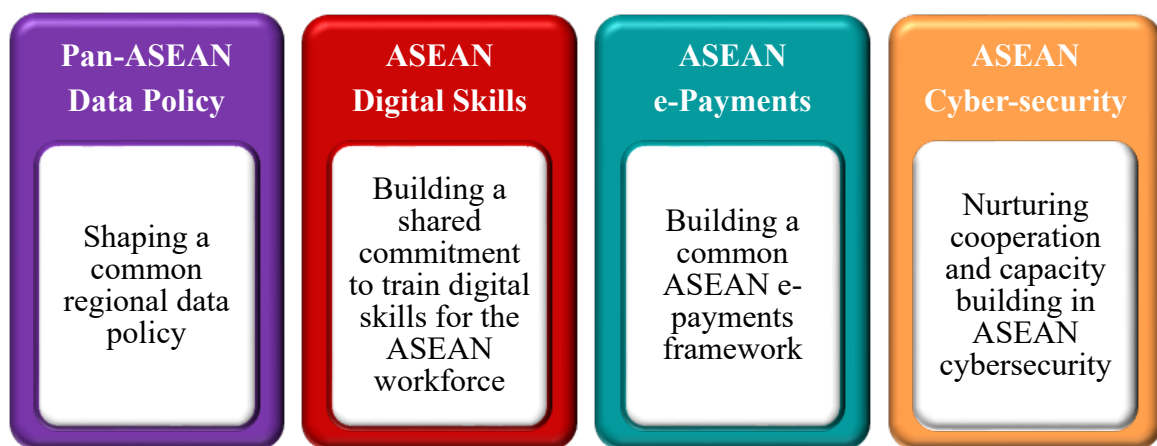


Figure 1.1: Focus Areas of Digital ASEAN Initiative

Source: Adopted from World Economic Forum (2018a)

The scope of work of the Digital ASEAN initiative is illustrated in Figure 1.1. Each focus area has one task force that specifically work on it. In the area of digital skills, a programme namely ASEAN Digital Skills Vision 2020 has been launched in 2018 during an ASEAN meeting at Bangkok. The establishment is to train workers, regulators or moderators involved in digital sectors, and the extensive number of consumers in AMS. At that time, there were 21 organisations involved in the programme, taking up the commitments to cultivate more than ten million SMEs’ workers and to devote huge internship opportunities that about 30,000 placements. There were several commitments that were aimed to achieve by 2020 as shown in Figure 1.2.

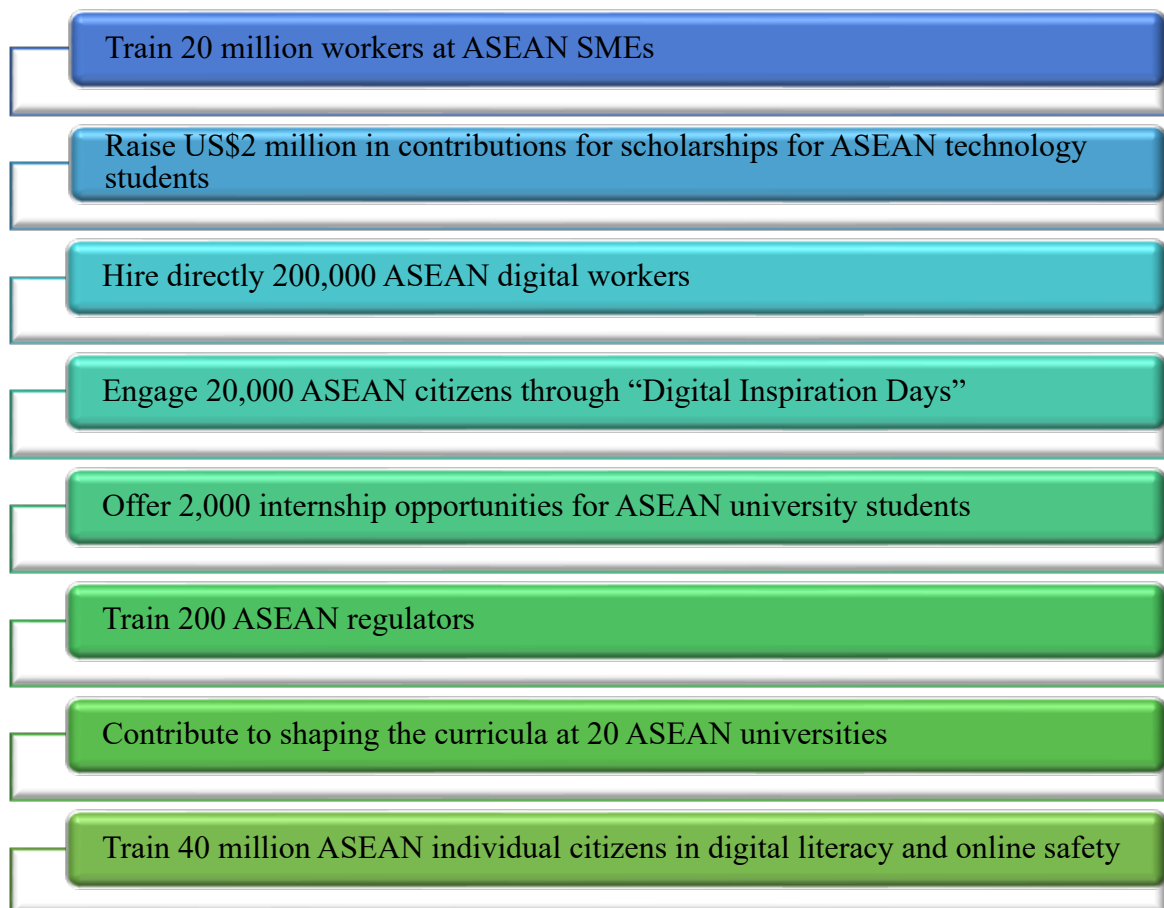


Figure 1.2: The Specific Commitments to be Achieved by 2020, ASEAN Digital Skills Vision 2020

Source: Adopted from World Economic Forum (2018b)

The ASEAN e-Payments Coalition was established in the first quarter of 2019 to facilitate the growth of cross-border e-commerce among ASEAN member states. Comprising representatives from various sectors including banks, e-commerce firms, and regulators, the coalition aims to develop an integrated digital payments framework for the region. Collaborating closely with the ASEAN Working Committee on Payment and Settlement Systems (WC-PSS), the coalition has conducted several working meetings to formulate strategic recommendations on e-payments, which are intended to shape the payment policy framework in ASEAN. Efforts are ongoing to establish a consistent input process that can be continuously integrated into the work of WC-PSS.

Regarding data policy, members of the working group remain committed to developing and supporting the implementation of the ASEAN Digital Data Governance Framework. They have shared their data classification practices with parties involved in building the framework on behalf of ASEAN governments. Additionally, they have participated in various dialogue activities organized by the Forum's International Trade and Investment Platform to discuss issues such as trade policy and cross-border data flows.

Another area of focus is cybersecurity. To promote teamwork and capacity building in ASEAN cybersecurity, members of the task force have been looking at models for cybersecurity intelligence sharing and identifying the types of interventions needed. They developed ideas on cybersecurity priorities and themes to be incorporated into the 2020 ASEAN Agenda. Table 1.2 shows the 2020 Global Cybersecurity Index (GCI) ranking of AMS in Asia-Pacific region. This is the latest ranking released by ITU. Singapore and Malaysia performed outstandingly in cybersecurity aspect where they were even among the top ten in the global rank. However, the ranking also indicated that there were huge gaps with other AMS. Cybersecurity is always the concern of netizen which directly affects their

usage of the Internet. This serves as a reminder to ASEAN bloc whereby improving cybersecurity to reduce the gap among AMS is equally important as developing in other aspects so that this will not be a roadblock to form the regional digital economy.

Table 1.2: GCI 2020 Ranking in Asia-Pacific Region

Member State	Score	Regional Rank	Global Rank
Korea	98.52	1	4
Singapore	98.52	1	4
Malaysia	98.06	2	5
Japan	97.82	3	7
India	97.49	4	10
Australia	97.47	5	12
Indonesia	94.88	6	24
Vietnam	94.55	7	25
China	92.53	8	33
Thailand	86.50	9	44
⋮		⋮	
Philippines	77.00	13	61
Brunei Darussalam	56.07	16	85
Myanmar	36.41	18	99
Lao P.D.R.	20.34	25	131
Cambodia**	19.12	26	132

Notes: A total of 194 countries around the world are on the global ranking list, including 38 countries in the Asia-Pacific region. ** indicates the country had no response to the questionnaire and thus affected data collection by GCI team.

Source: Global Cybersecurity Index (GCI), 2021, International Telecommunication Union

To build ASEAN Digital Economy, World Bank (2019) in their report “The Digital Economy in Southeast Asia – Strengthening the Foundations for Future Growth” also points

out several key focus areas as shown in Figure 1.3 that are almost similar to that of the ASEAN Digital Initiatives by WEF.



Figure 1.3: Key Focus Areas for ASEAN Digital Economy

Source: Adopted from World Bank (2019)

Among others, connectivity development is the first issue on the agenda. In Southeast Asia region, half of the populations are internet users and this is on par with the global average. Nevertheless, the penetration rate of internet users could further be expanded with policies and actions on making the connection more affordable with lowering prices, increasing internet speeds, and offering reliable and stable broadband internet to underserved areas. As shown in Figure 1.5, countries other than Singapore, Thailand, and Malaysia are actually having broadband speeds that are much lower than the global average, making it one of the biggest issues for business digitisation and data-intensive business applications.

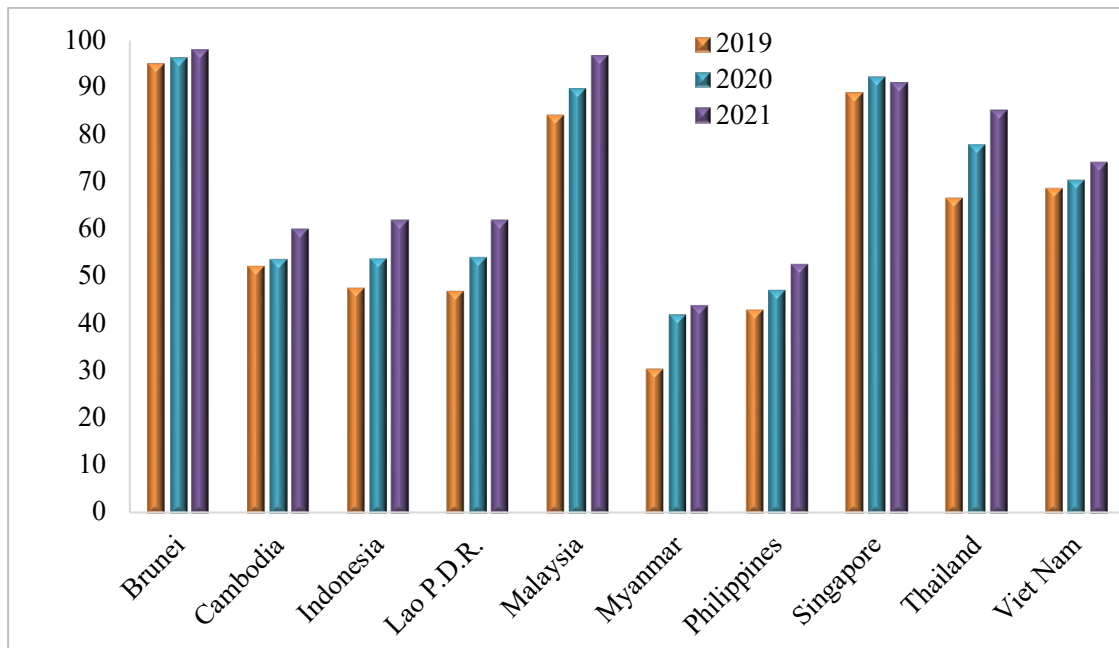


Figure 1.4: Individuals using the Internet in AMS, 2019-2021

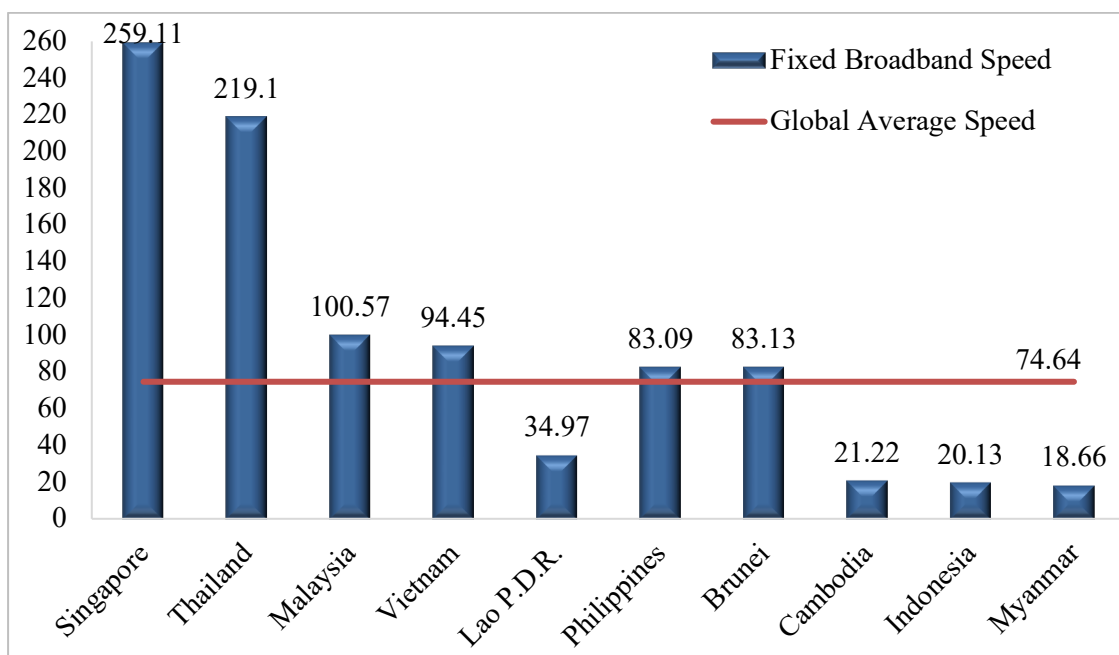


Figure 1.5: Fixed Broadband Speed of AMS, March 2020

Source: Speedtest Global Index (2020)

ASEAN is now with a population of over 650 million people. Strengthening and cultivating the digital skills among this population could definitely open up extensive

opportunities for them and leverage more benefits from digital transformation. Even though some of the countries in the region have rather good literacy and numeracy rates, there are still education development gaps among the member countries. Therefore, flexible education systems are sought after to educate the populations with basic skills to use computer and then equip them with more advanced skills such as learning programming language, do coding and data analytics. Soft-skills such as communication, leadership, and teamwork are also essential. Afterall, these are important aspects to be mastered in order to enable themselves to fit in the digital era.

Apart from that, digital payments are also another priority in the developing digital economy. World Bank data reveals that among the financial account holders in this region, only 19 percent of them access their accounts using Internet. This is quite below than the average in middle income countries (27 percent) and in Sub-Saharan Africa (24 percent). Building appropriate regulatory infrastructure is crucial, while the ASEAN governments can also digitalise public services, which can have more interactions with its citizen and at the same time can increase and improve the use of digital payments.

When it comes to the integration of technology into business, e-commerce plays a vital role. However, logistics is an obstacle in e-commerce with the issues of delivering products and reliability concerns. It is always a challenge for this industry to reach cost-effectiveness and build up trustworthiness in the process of delivering products to consumers in the destined location. There are customs procedures that e-commerce shipments cannot avoid in many countries, and even World Bank data also shows that logistic sectors in this region perform weakly in the customs area.

In order to increase and improvise the participation in the digital economy, promoting and strengthening trust in policies that concern on privacy of data, consumer protections,

and online security could help. Indeed, fewer than half of ASEAN member states have implemented comprehensive data protection laws, and authorities and stakeholders involved have limited capacities in enforcing data protection measures. Additionally, there is a lack of harmonization in policies across the region, posing challenges for individuals and businesses in understanding applicable regulations when transferring data across borders.

Last but not least, ASEAN governments shall also provide some digital-service-based platforms to support business digitalization. It can also reduce the times and costs of transactions such as online licensing and permit approvals. The frameworks of ASEAN Economic Community (AEC) Blueprint 2025, e-ASEAN Framework Agreement, as well as the Masterplan on ASEAN Connectivity 2025 do address the issues as discussed. It is encouraged to have more study or research, attentive policy-making and harmonising regional involvements will further move ASEAN to a better position and leverage fully to the digital transition and transformation process.

1.2.2 Overview of AMS Rank in Various Digital Indexes

At present, there are various digital-related indexes being published with respect to predefined goals by different organisations. Among others, there are 11 indexes in Table 1.4 include Network Readiness Index, Digital Adoption Index, ICT Development Index, IMD World Digital Competitiveness, Global Digital Readiness Index, Asian Digital Transformation Index, Global Connectivity Index, Mobile Connectivity Index, Web Index, Digital Society Index and Affordability Index. These indexes are selected because their measurements or rankings involve certain or all AMS. It can be seen from Table 1.4 that different indexes with distinctive goals cause the AMS to rank differently, but Singapore and Malaysia mostly rank first and second, respectively, within AMS. Due to the fact that digitalisation transforms economies significantly and the transition process involves a wide

range of aspects, efforts have never stopped in order to figure out how the countries are doing in various digital perspectives. It mostly depends on the self-interest of organisations and their predefined purposes to create and construct such indexes. Hence, comparisons of one index to another is not feasible and not appropriate because they carry different aims with a variety of digital dimensions and components in their basket of measurement. The details of the selected indexes are described further in Chapter 2 Literature Review because it affects and directs the present study to consider and select suitable digital components as well as the methods to construct digital economy performance indicator for AMS.

Table 1.3: Ranking and Scores of AMS in Various Digital Indices

No.	Index	Organisation	Year	Total Countries	AMS	#Rank [Score]
1.	Network Readiness Index	Portulans Institute	2019	121	Singapore Malaysia Thailand Vietnam Philippines Indonesia Cambodia Lao P.R.	#2 [82.13] #32 [63.76] #56 [51.54] #63 [49.57] #71 [47.70] #76 [46.15] #107 [32.29] #108 [31.88]
2.	Digital Adoption Index ^a	World Bank	2016	180	Singapore Malaysia Brunei Thailand Vietnam Philippines Indonesia Cambodia Lao P.D.R. Myanmar	#1 [0.87] #41 [0.68] #58 [0.62] #61 [0.61] #91[0.52] #101 [0.49] #109 [0.45] #123 [0.39] #159 [0.25] #160 [0.25]

Table 1.3 continued

3.	ICT Development Index	International Telecommunication Union	2017	176	Singapore Brunei Malaysia Thailand Philippines Vietnam Indonesia Cambodia Myanmar Lao P.D.R.	#18 [8.05] #53 [6.75] #63 [6.38] #78 [5.67] #101 [4.67] #108 4.43] #111 [4.33] #128 [3.28] # 135 [3.00] #139 [2.91]
4.	IMD World Digital Competitiveness	IMD World Competitiveness Center	2019	63	Singapore Malaysia Thailand Philippines Indonesia	#2 [99.37] #26 [82.93] #40 [68.43] #55 [59.44] #56 [58.01]
5.	Asian Digital Transformation Index	The Economist Intelligence Unit	2018	11	Singapore Malaysia Thailand Philippines Indonesia	#1 [78.00] #6 [36.90] #9 [23.00] #10 [12.80] #11 [12.20]
6.	Global Digital Readiness Index ^b	Cisco	2019	141	Singapore Malaysia Thailand Vietnam Indonesia Philippines Cambodia Laos Myanmar	#1 [20.26] #38 [14.31] #55 [13.21] #70 [12.06] #73 [11.68] #81 [11.03] #102 [9.27] #107 [8.58] #111 [8.08]

Table 1.3 continued

7.	Global Connectivity Index	Huawei	2019	79	Singapore Malaysia Thailand Vietnam Philippines Indonesia	#4 [81.00] #30 [54.00] #54 [43] #57 [37] #59 [37] #62 [36]
8.	Mobile Connectivity Index	GSMA	2018	165	Singapore Thailand Malaysia Brunei Vietnam Indonesia Philippines Myanmar Cambodia Lao P.D.R.	#2 [86.62] #48 [68.25] #52 [67.41] #55 [67.28] #65 [64.98] #75 [61.83] #76 [61.59] #107 [51.38] #120 [47.06] #127 [43.93]
9.	Web Index	World Wide Web Foundation	2014	86	Singapore Philippines Malaysia Indonesia Thailand Vietnam Myanmar	#22 [75.16] #41 [48.87] #42 [48.34] #52 [39.27] #53 [39.20] #67 [24.89] #85 [3.03]
10.	Digital Society Index ^c	Dentsu Aegis Network	2019	24	Singapore Thailand	#1 #20
11.	Affordability Index	Alliance	2019	61	Malaysia Thailand Indonesia Vietnam Philippines Cambodia Myanmar	#1 [85.33] #8 [70.34] #16 [63.24] #24 [59.30] #26 [57.90] #38 [51.57] #43 [46.67]

Sources: 1. Portulans Institute (2019); 2. World Bank (2016); 3. International Telecommunication Union (2017); 4. IMD World Competitiveness Center (2019); 5. The Economist Intelligence Unit (2018); 6. Cisco (2020); 7. Huawei (2019); 8. GSMA (2018);

9. World Wide Web Foundation (2014); 10. Dentsu Aegis Network (2019); 11. Alliance for Affordable Internet (2019); a. Scores ranging on a scale from 0 to 1.; b. Scores ranging on a scale from 0 to 25; c. The scores are not publicly available.

1.3 Problem Statement

Upon taking over the rotating chairmanship of ASEAN on 1st January 2018, Singapore demonstrated its ambition as a leading Asian Tiger to establish a “single digital market” within ASEAN. This initiative aims to integrate the ten ASEAN Member States (AMS) into a unified digital entity that fosters innovation, connectivity, and economic growth. However, the persistent digital divide—manifested through disparities in internet infrastructure, technological adoption, and institutional capacities—poses a significant challenge to achieving this vision. These gaps threaten to undermine Singapore’s regional plan and hinder ASEAN’s aspiration to become a global hub for technological advancement.

While ASEAN has initiated the ASEAN Digital Integration Index (ADII) to measure digital integration efforts, the ADII has limitations that reduce its effectiveness in addressing the unique challenges of AMS. The ADII focuses primarily on the dynamic process of reducing the digital divide but lacks a comprehensive and quantifiable measure to evaluate digital economy performance across multiple dimensions. Specifically, the ADII does not:

- i. Provide a detailed intra-country analysis to identify digital performance across various dimensions within individual AMS.
- ii. Offer a comparable framework for inter-country analysis to assess relative performance and digital development levels across AMS.
- iii. Capture the multidimensional nature of the digital economy, such as infrastructure, digital skills, and economic utilization of digital technologies.

Existing research further exacerbates these limitations by concentrating on isolated aspects of digitalization—such as internet penetration or e-commerce growth—without

delivering a holistic view of digital economy performance. Moreover, previous studies have not addressed the structural heterogeneity within ASEAN economies, which have varying levels of readiness and capacity for digital adoption. While examples like China and India are often cited, their contexts differ fundamentally, and lessons from these countries cannot be directly applied to ASEAN without considering regional realities.

This study addresses these gaps by constructing a Digital Economy Performance Index (DEPI) tailored specifically for AMS. Unlike the ADII, the DEPI offers a multidimensional, quantifiable measure that evaluates digital economy performance across diverse dimensions, including infrastructure, innovation, digital inclusion, and economic outcomes. It provides a more robust framework to monitor progress, identify disparities, and guide policy interventions.

The digital divide within ASEAN reflects significant economic and social disparities among member states, driven by factors such as unequal access to digital infrastructure, variations in income levels, and differences in institutional capacity. This divide results in social exclusion, where individuals, communities, or entire nations are marginalized and unable to fully participate in the digital economy.

Social exclusion refers to the systematic exclusion of certain groups from social, economic, and technological opportunities, often reinforcing inequalities and limiting access to the benefits of digital transformation. In the context of ASEAN, this exclusion can manifest as limited digital connectivity in rural areas, lack of access to digital skills training, or the inability of lower-income countries to integrate into the regional digital economy.

The present study of clustering diagnostic variables in each dimension and calculating the index scores of all components has the potential to serve as: 1) Intra-country analysis, which is to indicate or signal the individual member country to identify the pace or

performance through reading of individual and overall index scores. From the index score, it allows different priorities known across countries that may influence their relative digital economy trajectories. From there, the country itself could make a relative plan to enhance or improve its digital adoption and performance. For countries that are making effort to diminish the gap of technological and development, this study may, to certain extent, help out to lessen a middle-income trap. 2) Inter-country analysis, which can cluster and compare countries according to their index scores. The construction of the Digital Economy Performance Index (DEPI) in this study aims to address the gaps that contribute to social exclusion. Unlike the ASEAN Digital Integration Index (ADII), which primarily focuses on measuring digital integration efforts, the DEPI emphasizes performance across key dimensions of the digital economy. It identifies specific weaknesses and disparities at both intra-country and inter-country levels, allowing policymakers to address the roots of social exclusion by implementing targeted strategies for digital inclusion and economic convergence.

By diagnosing the state of digital economy performance in individual ASEAN Member States (AMS), this study highlights the critical need to reduce social exclusion and foster inclusive digital development. Addressing social exclusion through informed policy measures can help bridge the development gap, ensuring that no country or community is left behind in ASEAN's pursuit of a single digital market and regional technological growth.

1.4 Research Question

To address this research problem, the study investigates the following key questions:

- i. How does each AMS perform in different dimensions of the digital economy?
- ii. What is the overall digital economy performance of each AMS?

- iii. Which AMS are at similar levels of digital development, and how do they cluster regionally?

1.5 Objectives of the Study

Primarily, this study aims to assess the level of digital economy development among ASEAN Member States (AMS) by constructing a Digital Economy Performance Indicator (DEPI). The specific objectives of this study are as follows:

- i. To measure the level of digital development across key dimensions of the digital economy for each AMS using individual index scores, providing insights into the strengths and weaknesses of specific dimensions at the country level;
- ii. To construct an aggregated digital economy performance index that reflects the overall digital economy performance of each AMS, allowing for a holistic comparison of digital development across the region; and
- iii. To classify AMS into distinct groups based on their aggregated digital economy performance index scores, enabling the identification of countries at similar levels of digital development for benchmarking and regional policy coordination.

1.6 Significance of the Study

The current study, which involves clustering diagnostic variables within each dimension of the digital economy, addresses notable research gaps in the literature. Existing studies have largely focused on individual indicators or regional initiatives, such as the ASEAN Digital Integration Index (ADII), which emphasizes digital integration but fails to comprehensively measure digital economy performance across ASEAN Member States (AMS). While previous research has underscored the importance of digital infrastructure, connectivity, and innovation, there remains limited understanding of how each AMS

performs in distinct dimensions of the digital economy and how these performances influence economic convergence and the reduction of development gaps.

Furthermore, traditional weighting models for digital economy assessment often rely on subjective approaches, introducing bias in indicator selection and prioritization. This study overcomes this limitation by utilizing the entropy weight method (EWM), a prominent and widely validated model for information weighting. Unlike subjective methods, EWM eliminates human bias, as it objectively determines the weight of indicators based on data dispersion. The higher the level of differentiation among measured values, the higher the weight assigned to the corresponding index. This methodology enhances the objectivity and reliability of comprehensive evaluations, ensuring that the results reflect the true disparities and priorities within and across countries.

By constructing the Digital Economy Performance Index (DEPI), this study fills two critical research gaps:

i. Intra-country Analysis:

The DEPI allows individual countries to identify their progress and weaknesses across different dimensions of the digital economy. This granular understanding helps governments prioritize initiatives that address critical areas, such as digital infrastructure, skills development, and technology adoption. The study also highlights how informed digital strategies can mitigate the risk of falling into the middle-income trap, which remains a persistent challenge for several AMS.

ii. Inter-country Analysis:

At a regional level, the DEPI clusters countries based on their performance, enabling policymakers to visualize digital development transitions over time using self-organizing

map techniques. This regional perspective fosters economic convergence by identifying development gaps and areas requiring intervention, thereby supporting ASEAN's broader vision of reducing socio-economic and geographic disparities.

The study's significance lies in its ability to provide a holistic, data-driven assessment of digital economy performance, which is currently lacking in the ASEAN context. While existing frameworks like the ADII address digital integration, they do not offer insights into performance differentiation or cluster-based development trajectories. By filling these gaps, this study makes the following contributions:

- i. It advances understanding of what we know—the growing importance of digital economies and the role of digital transformation in driving regional development.
- ii. It highlights what we do not know—the relative performance and priorities of individual AMS in distinct dimensions of the digital economy.
- iii. It offers actionable insights for policymakers to address digital disparities, reduce social exclusion, and promote inclusive digital growth.

Ultimately, this study contributes to both theoretical understanding and practical policymaking by equipping stakeholders with a robust tool (DEPI) to measure, monitor, and enhance the digital economy performance of ASEAN member countries.

1.6.1 Novelty

The expected results generated from EWM analysis would be a new finding and a great breakthrough for AMS. This is because the research is able to enlighten the disparities in different dimensions of digital economy performance within a member country itself and pertinent policy could be well-directed to comprehensively propel the country towards digital economy. Moreover, the discrepancy of economic digitalisation level among member countries in the bloc that would be resulted from this research could enhance the progress of

economic convergence and reduce development gap within the regions as well as support the development of regions that are peripheral both from socio-economic and geographic perspectives.

1.6.2 Potential Applications

The intra-country based analysis on economic digitalisation level of each member country lays the potential application to direct their policymakers making different priorities that may influence their respective digital economy trajectories. It could also enhance or improve its digital adoption and performance towards victorious direction in attaining digital economy sustainability. The inter-country-based analysis on the other hand, could provide useful insights for the ASEAN bloc as a whole to improve and strengthen digital integration, and grow stronger to be a key digital economy in the world.

1.6.3 Impact on Social, Economy and Nation

This study has the potential to generate substantial societal impact by promoting enhanced productivity growth through innovation, technology, and the development of human resources. Furthermore, it could bolster the economy and national progress by fostering increased regional research and development geared towards commercial application, thereby enhancing the competitive advantage of each member country. Additionally, it has the capacity to elevate the industry value chains within the ASEAN bloc to a more advanced level characterized by greater technology and knowledge intensity.

1.7 Scope of the Study

This study intends to construct digital economy performance indicator for all ten AMS that shows their level of digitalisation across different dimensions. Yearly data from 2017 to 2021 are used to construct the indicator. The structure of this study is arranged as follows: Chapter 1, Introduction; Chapter 2, Literature Review; Chapter 3, Methodology;

Chapter 4, Results and Discussions; and end with Chapter 5, Conclusion and Recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There is a considerable number of global organisations measuring digitalisation indices, but they vary in terms of specific goals, priorities, and context of the analysis. These resources can serve as a starting point for understanding the literature and previous works on measuring digital-relevant indices. They provide insights into different methodologies, variables, and challenges associated with constructing such indices, which are reviewed in this chapter. The following sections are as follow: Section 2.2 pinpoints some digital indices that are formulated by global organisations, Section 2.3 reviews on how other researchers define digital economy and the approaches they used to measure digital economy as well as identify digital divide, and Section 2.4 summarises the gap identified in the literature.

2.2 Theoretical Review

This section introduces theories relevant to the digital economy and its performance measurement, focusing on how they inform the construction of the Digital Economy Performance Indicator (DEPI).

2.2.1 Technology Acceptance Model (TAM) (Davis, 1989)

The Technology Acceptance Model (TAM) developed by Davis (1989) provides a framework to understand how individuals adopt and use new technologies. TAM posits that two primary factors influence technology acceptance:

- i. Perceived Usefulness (PU): The degree to which a person believes that using a particular technology will enhance their performance.

- a. E-Government Usage: Reflects how digital technologies enhance public service delivery efficiency.
 - b. E-Commerce Penetration: Shows the value of digital adoption in improving economic activity and market accessibility.
 - c. Digital Payments Adoption: Demonstrates practical benefits of financial inclusion and transaction efficiency.
- ii. Perceived Ease of Use (PEOU): The extent to which a person believes that using the technology will be free from effort.
 - a. Connectivity (e.g., Broadband Penetration, Mobile Network Coverage): Higher accessibility reduces technological barriers.
 - b. Affordability (e.g., Internet Cost as % of Income): Affordable digital tools enhance perceived ease of use.
 - c. Human Capital (e.g., ICT Skills, Digital Literacy Rates): Ensures users have the skills to adopt technology effortlessly.

- iii. Behavioral Impact (Classification):

The classification of AMS based on aggregated index scores aligns with TAM's idea that ease of use and usefulness determine adoption levels. Countries with higher digital readiness (e.g., better connectivity, affordability, and skills) are likely to adopt technologies faster, leading to higher scores.

In the context of ASEAN, these factors are critical for understanding the adoption of digital technologies across varying socio-economic contexts. For instance:

- i. Countries with higher digital literacy and better internet accessibility are likely to score higher in Perceived Ease of Use, facilitating quicker adoption of digital platforms.

- ii. The Perceived Usefulness of digital technologies in improving economic productivity, education, and public services plays a significant role in driving digital adoption.

The DEPI integrates this framework by evaluating human capital (which relates to PEOU) and digital technology integration (which relates to PU). By assessing these dimensions, the DEPI captures the readiness of AMS to accept and leverage digital technologies, shedding light on areas where interventions are needed to enhance technology acceptance and utilization.

2.2.2 Innovation Diffusion Theory (Rogers, 1962)

This theory explains how innovations, including digital technologies, spread within societies over time. According to Rogers (1962), the adoption process is influenced by factors such as relative advantage, compatibility, and complexity. In the context of ASEAN, varying levels of digital infrastructure, cultural readiness, and institutional capacity contribute to the differential adoption rates of digital technologies across member states. The DEPI incorporates this perspective by evaluating dimensions such as connectivity and human capital, which influence the diffusion of digital technologies.

Innovation Diffusion Theory explains how innovations, such as digital technologies, are adopted and spread within a society or region over time. The theory identifies factors that influence adoption, such as relative advantage, compatibility, complexity, trialability, and observability. These factors informed the selection of key variables for the study's Digital Economy Performance Indicator (DEPI) to reflect the readiness and capacity of ASEAN Member States (AMS) to adopt and integrate digital technologies.

The following variables were selected based on the principles of the theory:

i. Connectivity:

Innovation Diffusion Theory suggests that access to infrastructure is a critical enabler of technology adoption. Variables such as broadband penetration, mobile network coverage, and internet speed reflect the availability and accessibility of the digital infrastructure necessary for technology diffusion across AMS. These variables capture the foundation for adopting digital innovations.

ii. Human Capital and Digital Skills:

The theory highlights the importance of compatibility—the alignment between the innovation and the existing skills of the adopters. For AMS, variables such as digital literacy rates, ICT skills in the workforce, and education levels are critical to understanding how equipped individuals are to adopt and effectively use digital technologies. These variables represent the human readiness dimension for innovation diffusion.

iii. Technology Adoption:

Observability and trialability are key factors in the diffusion process. Variables such as e-commerce penetration, digital payment usage, and adoption rates of ICT tools were included to measure how visible and accessible digital innovations are in AMS. These indicators reflect the extent to which countries integrate digital technologies into their economic and social systems.

By considering these dimensions, the DEPI aligns with the Innovation Diffusion Theory by capturing the key factors that facilitate or hinder the spread of digital technologies across AMS.

2.2.3 Digital Divide Theory (Norris, 2001)

The digital divide theory emphasizes the socio-economic disparities caused by unequal access to digital technologies. Norris (2001) identifies three forms of digital divides:

- i. Global Divide: Differences in digital access between developed and developing regions.
- ii. Social Divide: Inequalities within countries, such as urban-rural gaps in internet access.
- iii. Democratic Divide: Inequalities in how individuals leverage digital technologies for political and economic participation.

In ASEAN, the digital divide manifests in areas like internet penetration, affordability, and digital literacy. The DEPI accounts for these divides by including indicators that measure digital connectivity, affordability, and skills. These measures align with the goal of reducing digital exclusion and fostering digital inclusion, a critical step toward equitable economic development. The following variables were chosen based on the theory:

- i. Infrastructure Access:

The global digital divide relates to disparities in access to foundational digital infrastructure. Variables such as internet penetration rates, broadband affordability, and mobile network coverage reflect the varying levels of infrastructure availability across AMS, which is a primary driver of the digital divide.

- ii. Affordability of Digital Technologies:

The social digital divide is influenced by income disparities and the affordability of digital tools. Variables like cost of internet services (as a percentage of income) and mobile

data affordability were included to measure how socio-economic factors affect individuals' ability to access digital technologies.

iii. **Digital Literacy and Skills:**

The theory highlights that unequal levels of digital literacy exacerbate the social digital divide. Variables such as ICT skills, percentage of digitally skilled workforce, and educational attainment rates capture the disparity in individuals' ability to effectively use digital technologies.

2.3 Digital Indices by Global Organisations in Recent Years

Digital-related indices are plentifully available with various goals. From the background of the study, it enlightens the focus areas in developing a framework of measuring digitalization level in AMS economics. The present study has identified five main dimensions, i.e., connectivity infrastructure, human capital, Internet services, business digitisation, and digital government. This section further reviews on several digital indices that are affecting and shaping the present study in defining and constructing digital economy performance indicator (DEPI) for AMS. These indices lead the study to form attentive sub-dimensions, to select suitable components in the DEPI basket, as well as the appropriate methods to be used in construction.

2.3.1 Digital Economy and Society Index by European Commission

The Digital Economy and Society Index (DESI) was introduced by the European Commission (EC) in 2014 as part of the 'Digital Single Market Strategy'. It serves as a composite index that consolidates relevant indicators on Europe's digital performance, thereby tracking the progress of European Union (EU) member states in terms of digital competitiveness on an annual basis. The latest DESI for the year 2022, outlined in Table 2.1, comprises four main dimensions, each consisting of a set of sub-dimensions and individual

indicators. These indicators are selected based on considerations from both the supply and demand sides of the digital economy. Within the structure of DESI, certain dimensions, sub-dimensions, and individual indicators are deemed more relevant or important for Europe countries, leading the EC to assign higher weights to these aspects before aggregating them into a single index. In the most recent release of the 'Digital Economy and Society Index Methodological Note' by the European Commission (2022), equal weightage of 25 percent has been assigned to each of the four dimensions. This represents a departure from the varying weightage assigned since the inception of DESI in 2014. The Commission has made these adjustments to DESI to align it with the objectives outlined in the Commission proposal for a Decision titled 'Path to the Digital Decade', which is currently under negotiation by the co-legislators. This proposal sets EU-level targets to be achieved by 2030, aiming to facilitate a comprehensive and sustainable digital transformation across all sectors of the economy. Eleven of the indicators in DESI 2022 are designed to measure progress towards the Digital Decade targets. Going forward, DESI will be further aligned with the Digital Decade objectives to ensure that all targets are adequately addressed in the reports.

Table 2.1: Structure of the DESI 2022

Dimension	Sub-dimension	Indicator
Human Capital	Internet user skills	At least basic digital skills
		Above basic digital skills
		At least basic digital content creation skills
	Advanced skills and development	ICT specialists
		Female ICT specialist
		Enterprises providing ICT training
		ICT graduates
Connectivity	Fixed broadband take-up	Overall fixed broadband take-up
		At least 100 Mbps fixed broadband take-up
		At least 1 Gbps take-up
	Fixed broadband coverage	Fast broadband (NGA) coverage
		Fixed Very High Capacity Network (VHCN) coverage
	Mobile Broadband	5G spectrum
		5G coverage
		Mobile broadband take-up
	Broadband prices	Broadband price index
Integration of Digital Technology	Digital intensity	SMEs with at least a basic level of digital intensity
	Digital technologies for businesses	Social media
		Big data
		Cloud
		AI
		ICT for environmental sustainability
		e-Invoices
	e-Commerce	SMEs selling online
		e-Commerce turnover
		Selling online cross-border

Table 2.1 continued

Digital Public Services	e-Government	e-Government users
		Pre-filled forms
		Digital public services for citizens
		Digital public services for businesses
		Open data

Source: European Commission (2022)

There are several studies that apply DESI in their research. For example, Nagy (2017) analyses the status of DESI in Hungary, then compares it with Ukraine and made conclusions regarding the future development tendencies. Another example is from the study of Stavytsky, Kharlamova, and Stoica (2019) that determines the development of digital economy using 28 European countries with structural units of DESI and tests a few hypotheses using panel regression analysis.

2.3.2 International DESI by European Commission

The digital economy is not confined to Europe alone; it is a global phenomenon. In a bid to enhance the performance of the EU's digital economy while also leveraging the process of digitalization, the European Commission (EC) has introduced and established the International Digital Economy and Society Index (I-DESI). This framework facilitates the review and comparison of digital performance at a global level, wherein the digital performance of 28 EU member countries is compared with that of 17 countries outside the European region using the DESI methodology. The non-EU countries encompass Australia, Brazil, Canada, Chile, China, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Russia, Serbia, South Korea, Switzerland, Turkey, and the United States. The objective of I-DESI is to replicate and expand upon the results of the European Commission's Digital Economy and Society Index (DESI) by identifying indicators that measure similar variables for non-EU countries. I-DESI employs 24 indicators and applies a weighting system to rank each country

based on its digital performance, thereby establishing a benchmark for the development of the digital economy and society. It utilizes the same dimensions or policy areas as DESI to assess performance. However, due to variations in digital indicators among the 17 non-EU countries, the structure of I-DESI has been modified from that of DESI for EU member countries.

Table 2.2: Structure of the I-DESI 2018

Dimension	Sub-dimension	Indicator
Connectivity	Broadband coverage and take-up	Fixed broadband coverage
		Fixed broadband take-up
	4G coverage and mobile take-up	Mobile broadband take-up
		4G coverage
	Fast broadband coverage and take-up	NGA coverage
		Subscriptions to fast broadband
	Fixed broadband prices	Fixed broadband price
Human Capital	Basic skills and usage	Internet users
		Regular internet users
	Advanced skills development	Employed in knowledge-intensive activities
		Tertiary graduates in ICT
Citizen internet use	Content	News
	Social media	Average number of devices used
		Social networks
	Transactions	Banking
		Internet shoppers as a % of population
	Devices	Average number of devices used
Business Technology Integration	Business digitisation	Availability of latest technologies
		Firm-level technology absorption
		Social media

Table 2.2 continued

Public Services	e-Commerce	Business to business Internet use
		Secure Internet servers
	e-Government development index	E-Government Development Index
		Online service completion
		Open data

Source: European Commission (2018)

2.3.3 Network Readiness Index by Portulans Institute

The Networked Readiness Index (NRI) was first published in 2002 until 2016 in Global Information Technology Report (GITR) by the World Economic Forum (WEF) in collaboration with Cornell University and INSEAD. Its aim was to provide a holistic framework for countries with an interest to find out the multi-dimension impact of ICT on society and their development. In other words, Breene (2016) said that this networked readiness is a core index that measures and indicates how countries are doing digitally using wide-range of digital-related variables. The structure of NRI 2016 is shown in Table 2.3.

Table 2.3: Structure of NRI 2016

Pillar	Sub-Pillar	Components
Environment	Political and regulatory environment	Effectiveness of law-making bodies
		Laws relating to ICTs
		Judicial independence
		Efficiency of legal system in settling disputes
		Efficiency of legal system in challenging regs
		Intellectual property protection
		Software piracy rate
		No. procedures to enforce a contract
		No. days to enforce a contract

Table 2.3 continued

	Business and innovation environment	Availability of latest technologies
		Venture capital availability
		Total tax rate
		No. days to start a business
		No. procedures to start a business
		Intensity of local competition
		Tertiary education gross enrollment rate
		Quality of management schools
		Gov't procurement of advanced tech
Readiness	Infrastructure	Electricity production
		Mobile Network Coverage
		Int'l Internet bandwidth
		Secure Internet servers/million population
	Affordability	Prepaid mobile cellular tariffs
		Fixed broadband Internet tariffs
		Internet & telephony competition
	Skills	Quality of educational system
		Quality of math & science education
		Secondary education gross enrollment rate
		Adult literacy rate
Usage	Individual usage	Mobile phone subscriptions/100 pop.
		Individuals using Internet
		Households w/ personal computer
		Households w/ Internet access
		Fixed broadband Internet subscriptions
		Mobile broadband subs/100 pop.
		Use of virtual social networks

Table 2.3 continued

	Business usage	Firm-level technology absorption
		Capacity for innovation
		PCT patents, applications/million pop.
		ICT use for business-to-business transactions
		Business-to-consumer Internet use
		Extent of staff training
	Government usage	Importance of ICTs to gov't vision
		Government Online Service Index
		Gov't success in ICT promotion
Impact	Economic impacts	Impact of ICTs on business models
		ICT PCT patents, applications/million pop.
		Impact of ICTs on new organizational models
		Knowledge-intensive jobs
	Social impacts	Impact of ICTs on access to basic services
		Internet access in schools
		ICT use & gov't efficiency
		E-Participation Index

Source: WEF (2016)

In early 2019, WEF passed the production of NRI to Soumitra Dutta and Bruno Lanvin, the original editors of the index, after WEF reorganised internally and changed priorities. Within this opportunity, the editors revisited the context and made it more future-ready in the wake of new technological disruptions such as AI. They also changed the name from Networked Readiness Index to Network Readiness Index. They also created a special not-for-profit, the Portulans Institute to fully backup the research on the NRI. The NRI has been redesigned to reveal the situation on how integration between technology and people can be done with the appropriate governance structures (Portulans Institute, 2019). It covers a total of 121 economies in the world with 62 variables as shown in Table 2.4.

Table 2.4: Structure of the NRI 2019

Pillar	Sub-Pillar	Components
Technology pillar	Access	Mobile tariffs
		Handset prices
		Households with internet access
		4G mobile network coverage
		Fixed-broadband subscriptions
		International Internet bandwidth
		Internet access in schools
	Content	Digital participation and content creation
		Mobile apps development
		Intellectual property receipts
	Future Technologies	Availability of latest technologies
		Company investment in emerging technology
		Government procurement of advanced technology products
		ICT PCT patent applications
		Computer software spending
		Robot density
People pillar	Individuals	Internet users
		Active mobile-broadband subscriptions
		Use of virtual social networks
		Tertiary enrolment
		Adult literacy rate
		ICT skills
	Businesses	Firms with website
		Internet shopping
		Professionals

Table 2.4 continued

		Technicians and associate professionals
		Extent of staff training
		R&D expenditure by businesses
	Governments	Government online services
		Publication and use of open data
		ICT use and government efficiency
		R&D expenditure by governments and higher education
Governance pillar	Trust	Rule of law
		Software piracy rate
		Secure Internet servers
		Cybersecurity
		Online trust and safety
	Regulation	Regulatory quality
		Ease of doing business
		Legal framework's adaptability to digital business models
		E-commerce legislation
		Social safety net protection
		ICT regulatory environment
	Inclusion	E-Participation
		Socioeconomic gap in use of digital payments
		Availability of local online content
		Gender gap in internet use
		Rural gap in use of digital payments
Impact pillar	Economy	Medium and high-tech industry
		High-tech exports
		PCT patent applications
		Labour productivity per employee

Table 2.4 continued

	Quality of Life	Happiness
		Freedom to make life choices
		Income inequality
		Healthy life expectancy at birth
	SDG Contribution	Access to basic services
		Pollution
		Road safety
		Reading proficiency in schools
		Maths proficiency in schools
		Use of clean fuels and technology

Source: Portulans Institute (2019)

2.3.4 Digital Adoption Index by World Bank

Digital Adoption Index (DAI) was first known to public in 2016 when the World Bank published it in their report of “World Development Report 2016: Digital Dividends” (World Bank, 2016a). DAI is an index that measures the level of digital adoption across 180 countries in the world (World Bank, 2020). This index takes three main clusters into account, i.e. business, people (citizen), and government. They use a scale of 0 - 1, where zero indicates the lowest score and unity is the highest score. Different from other aforementioned indices, this DAI accentuates on the supply side of digital adoption so as to maximise coverage and simplify theoretical linkages as they claim. Table 2.5 shows the details of sub-indexes, components and indicators used in the construction of DAI. It is aggregated from the simple average of three clusters, where the components and indicators in each cluster are also assigned with average weight for simplicity.

Table 2.5: Structure of the DAI

Cluster	Component	Indicator
Business	Business websites	
	Secure servers	
	Download speed	
	3G coverage	
Citizens	Mobile-cellular access at home	
	Internet access at home	
	Cost of internet access	
Government		
Core Administration Sub-index	Financial management information system	Budget execution
		Budget formulation
		Treasury single account
		Source of financial data
	Human resources information system	HRMIS functionality
		e-payroll functionality
	e-tax	Tax management functionality
		e-filing functionality
	e-customs	e-customs functionality
	e-procurement	e-procurement functionality
Digital Identification Sub-index	Access to services	Range of services
	Digital signature	Signature functionality
	Card features	Card type
		Biometric functionality
Online public services sub-index		Online service index

Source: World Bank (2016b)

2.3.5 ICT Development Index by ITU

Since its inception in 2009, the ICT Development Index (IDI) has been recognized globally as a composite index that amalgamates 11 components into a single metric. It serves to monitor and facilitate comparisons between countries regarding their levels of development in information and communication technology (ICT) over time. The establishment of IDI aims to achieve several objectives: 1) Assess the performance of ICT development and its evolution over time within countries or in relation to other countries; 2) Evaluate the progress of ICT development in both developed and developing nations; 3) Identify the digital divide, or the gap in ICT development between countries; and 4) Analyze the potential of ICT development and the extent to which countries can leverage these outcomes to enhance growth and development, considering available capabilities and skills. Currently, IDI encompasses over 150 countries worldwide.

Table 2.6: Structure of the IDI

Sub-indices	Indicator
ICT access	Fixed-telephone subscriptions per 100 inhabitants
	Mobile-cellular telephone subscription per 100 inhabitants
	International Internet bandwidth per Internet user
	Percentage of households with a computer
	Percentage of households with Internet access
ICT use	Percentage of individuals using the Internet
	Fixed-broadband Internet subscriptions per 100 inhabitants
	Active mobile-broadband subscriptions per 100 inhabitants

Table 2.6 continued

ICT skills	Mean years of schooling
	Secondary gross enrolment ratio
	Tertiary gross enrolment ratio

Source: International Telecommunication Union (2020)

2.3.6 Mobile Connectivity Index by GSMA

Originally launched in 2016, Mobile Connectivity Index (MCI) measures 163 countries on the advancement level of their mobile internet ecosystem. They use a scoring system of 0 to 100. The final or total score is calculated based on four enablers, i.e. infrastructure, affordability, content and services, and consumer readiness. These indicators are based on 35 discrete indicators. Over the past few years, a number of similar indices have emerged, all related to connectivity. However, what makes MCI unique is its exclusive focus on mobile technology. This is important because mobile devices are now the primary way Internet users in low- and middle-income countries get online. A sign of its uniqueness is that more than half of the indicators that make up the Mobile Connectivity Index are not available or used in other similar indices.

When the index was first launched in 2016, it covered 134 countries, representing 95 percent of the world's population, and today this number has risen to 163 countries (99 percent of the world's population). MCI has also expanded through a number of enablers. For example, the "Content and Services" driver now includes data on the number of mobile apps developed in a specific country and whether they are available in local languages, which better represents local relevance. Additionally, the latest update means the MCI now has 4 years of data (covering 2014 to 2017). This indicates that countries' progress can be

examined over a long enough period of time to see significant changes in scores (GSMA, 2018).

Table 2.7: Structure of the MCI

Enabler	Dimension	Indicator
Infrastructure	Network Coverage	2G network coverage
		3G network coverage
		4G network coverage
	Network performance	Mobile download speeds
		Mobile upload speeds
		Latencies
	Other enabling infrastructure	International bandwidth per user Number of secure servers
		Access to electricity
		Number of Internet exchange points (IXPs)
	Spectrum	Digital dividend spectrum
		Other spectrum below 1GHz
		Spectrum in bands 1-3GHz
Affordability	Mobile tariffs	Cost of 100MB
		Cost of 500MB
		Cost of 1GB
	Handset price	Cost of entry-level internet-enabled handset
	Inequality	Inequality in income, Atkinson measure
	Taxation	Cost of taxation
		Cost of mobile- specific taxation
Consumer Readiness	Basic skills	Adult literacy rate
		School life expectancy
		Mean years of schooling
		Tertiary enrolment rate

Table 2.7 continued

	Gender equality	Gender years of schooling ratio
		Gender account access ratio
		Gender Gross National Income (GNI) per capita ratio
		Women, Business and the Law Index
		Gender gap ratio for social media use
		Gender gap ratio for mobile phone ownership
	Mobile ownership	Penetration of mobile users
Content and Services	Local relevance	Top-Level Domains (TLDs) per capita
		E-Government services
		Mobile social media penetration
		Mobile application development
	Availability	Number of apps in national language
		Accessibility of top ranked apps
	Online security	Global Cybersecurity Index

Source: GSMA (2018)

2.3.7 The Web Index by World Wide Web Foundation

The Web Index is established by the World Wide Web (WWW) Foundation. This index is first in the globe that examines the WWW's contribution to political, economic, and social progress for countries in the worldwide. It is designed with many different dimensions and is publicly available. It is believed that the construction of this index for 86 countries can sharpen understanding on how they actually seize the use and impact of the Web. It is an annual basis index that ranks counties and so opens up the potential to make comparison across countries over time and thus continuously improving netizen's knowledge of the Web's value for humanity.

Table 2.8: Structure of the Web Index

Sub-Index	Components	Secondary Indicator
Universal Access	Communications Infrastructure	% of population covered by mobile cellular network
		Broadband Speeds (peak Mbps, Average Mbps)
		Secure Internet Servers per million population
		IXPs (binary indicator: 0,1)
	Access and Affordability	Broadband subscribers per 100 populations
		Number of mobile phone subscribers per 100 population
		Internet Access in Schools
		Cost of fixed broadband per capita
	Education and Awareness	Cost of mobile broadband per capita
		Literacy rates
		Secondary school enrollment rates
		Ratio of female/male tertiary education
		School life expectancy (years) male / female
Freedom & Openness	Free and Open	Press Freedom Index
		Press Freedom
		Political Rights
		Civil Liberties
Relevant Content & Use	Content and Use	Government online services index
		% of individuals using the internet
		Dominant social network monthly active users

Table 2.8 continued

Empowerment	Economic Impact	Impact of ICT on organizational models
		Innovation Index
	Political Impact	E-Participation Index
		ICT use and government efficiency
	Social and Environmental Impact	

Notes: The construction of Web Index also involved 30 primary indicators which have not been further elaborated in this table. For details can refer to the report of Web Index 2014-2015.

Source: World Wide Web Foundation (2014)

2.3.8 Global Digital Readiness Index by Cisco

The Cisco Global Digital Readiness Index (GDRI) is established to help countries understand their position of readiness digitally to benefits from digitization (Cisco, 2019). They make thorough view of digital readiness through examining different factors that can reveal the development or progress that a country has made towards digital maturity. Other than this, the GDRI also aims to enlighten the strength aspects and provide guidance to improve their overall readiness. Secondly, the GDRI also provides insight into countries on their progress in digitalisation process. The structure of GDRI is shown in Table 2.9, with a maximum score of 25.

Table 2.9: Structure of GDRI

Digital readiness components	Metric
Basic Needs	Life Expectancy
	Mortality Rate (Under Age 5)
	Population Using Safe Drinking Water Services
	Access to Electricity

Table 2.9 continued

Business and Government Investment	Foreign Direct Investment
	Research and Development Expenditure
	Investment Freedom
Ease of Doing Business	Ease of Doing Business Index
	Rule of Law
	Logistics Performance Index (LPI) – Infrastructure Rating
	Time to Get Electricity
Human Capital	Labor Force Participation Rate
	Adult Literacy Rate
	Education Index (Years of School)
	Harmonized Test Score
Start-up Environment	New Business Density
	Patents Granted and Trademarks Registered
	Venture Capital Investment and Availability
Technology Adoption	Mobile Cellular Penetration
	Internet Usage
	Cloud Services (Spend, IT Forecast Data)
Technology Infrastructure	Mobile Broadband Subscriptions
	Fixed Broadband Subscriptions
	Secure Internet Servers
	Household Internet Access

2.4 Review of Previous Studies

2.4.1 Global Efforts in Digital Economy Measurement

Upon technological advancement in this era, the transition from agricultural economy, to manufacturing economy, service economy and now to digital economy is inevitable in all around the world. Digital economy creates enormous and infinite opportunities but at the same time, Kolomiets (2017) also opined that it alters the qualitative

transformation of economic relations. The development of digital economy is now getting much attention especially its conceptualization, as it can somehow serve as a basis for some political decisions. One significant initiative is shown by the WEF where it launches the NRI since 2002 to scrutinise how countries are doing in this digital world. It is an act upon recognition on the digital economy as a tremendous area for the future development of society.

In addition to the studies mentioned earlier that employed specific indices, Moroz (2017) utilized both the NRI and DESI to assess the advancement of the digital economy in Poland compared to Lithuania, Germany, Slovakia, and Italy. The findings revealed a concerning disparity in the level of utilization of ICT systems integration and the influence of ICT on the economy and society. Even though there were research studies as aforementioned using existing rankings and indicators such as NRI and DESI to assess digital divide or determine the level of digitalisation in economies, attention on ASEAN is especially scarce. It is well noticed that the evolution of digital economy is one of the leading drivers of economic growth, Garcia-Herrero and Xu (2018) developed an estimation of digital economy actual size in China apart from the existing international measurements because they opined that the current practices in measurement lack comparability. Meanwhile, Barefoot et al. (2018) gauged the contribution of digital economy towards U.S. overall economy with more comprehensive measures and made it a stepping stone for the establishment of their digital economy satellite account. These studies demonstrate the growing importance of digital economy indices in understanding technological adoption and its impact on national economies. However, such frameworks often overlook the diverse socio-economic and infrastructural conditions of regions like ASEAN.

2.4.2 Regional Studies and Limitations

Negrea et al. (2019) conceptually discussed and pointed out the priority areas that Romanian should lay their foundation on building new development policies to fully leverage digital transformation as Romania is facing huge gap in their digital skills. While one side aims to be the next digital economy, another side has already leap frog in the vanguard. In fact, China is now one of the greatest digital economies in the world that expands rapidly and creates enormous opportunities as digital transformation successfully reshapes China becoming a whole new country. Nevertheless, Zhang and Chen (2019) reminded China netizens on the potential risks during the way of seizing the benefits of digitalisation. The risks include potential labour disruption, privacy infringement, emerging oligopolies, and financial risks.

A few years ago, Atkinson and Wu (2017) acknowledged the growing significance of the digital economy and began incorporating it as a category in their construction of the State New Economy Index, which assesses the economies of 50 states in the U.S. Over time, the digital economy has expanded significantly, prompting new research efforts aimed at specifically measuring the level of digitalization in economies, with digital-related indicators being included in the assessment. Ojanpera et al. (2019) developed a Digital Knowledge Economy Index (DKEI) to assess the digital content creation, capabilities, and skills of populations, providing insights into the status of the world's digital knowledge economy. The study highlighted how the availability (or lack thereof) of digital resources can perpetuate inequalities in the data age. More recently, Elshin et al. (2020) proposed a measurement algorithm to evaluate the level of digital economy development in regions of the Russian Federation. Their study focused on five main areas: standard regulation, personnel for the digital economy, development of research competencies and technological

reserves, information structure, and information security, selected based on the digital economy landscape in Russia.

The methodology used by Ojanpera et al. (2019) and Elshin et al. (2020) is the standard package of calculating index, that is from standardization of data to normalization, and then weighting and lastly aggregation of index. Afterall, there is no benchmark or ruling on the choice of focus areas or dimensions to measure the level of digitalization of a country or a region. Instead, it is more to the digital condition of target research location and thus set a better fit of digital measurement. Consequently, it leads the present study to focus on several dimensions that are in concerns for ASEAN's digital development and thus proposes a series of measurement to determine the digitalization level of ASEAN economies.

Studies such as those by Ojanpera et al. (2019) developed the Digital Knowledge Economy Index (DKEI) to measure digital content creation and skills globally, providing useful insights into inequalities perpetuated by uneven access to digital resources. However, the study's findings highlighted that global indices often fail to capture the nuanced digital realities of developing regions.

For the ASEAN region, the ASEAN Digital Integration Index (ADII), published in 2021, represents a significant effort to measure digital integration. While the ADII focuses on the dynamic process of reducing the digital divide (digital inclusion), it lacks the comprehensive evaluation of digital economy performance. Specifically, the ADII:

- i. Emphasizes digital integration efforts but does not provide a holistic performance evaluation across critical dimensions like infrastructure, human capital, and digital adoption.
- ii. Does not allow for comparative analysis among AMS to identify regional leaders and laggards.

These limitations justify the need for a more tailored and multidimensional framework like the Digital Economy Performance Indicator (DEPI) proposed in this study.

2.4.3 Digital Divide and Measurement Challenges

The research of digital economy never ends due to the mass digital evolution in the world. Research interests vary, where some of them are concerning on the differences in digitalisation levels of countries in a region. This is because different countries are differing by the type of country, pace of development as well as socio-demographic and institutional variables, so there would be ‘digital divide’ of a country from one another. According to OECD (2001), ‘digital divide’ can be defined as “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to their opportunities to access information and communication technologies, and to their use for a wide variety of activities”. However, the problem of measuring the performance of digitalisation level is complex in considering what characterizes the performance as it cannot be singularly represented or explained by a measurement or indicator. This could be a reason why research in this interest of study requires the use of multivariate analytical methods. Among the studies include Billon et al. (2010), Mardikyan et al. (2015), and Cruz et al. (2017) that used factor and regression analysis; Balcerzak (2017), and Balcerzak and Pietrzak (2017) employed a multi-criteria decision analysis method known as Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS); and Moroz (2017) applied synthetic measure. On the other hand, Sidorov and Senchenko (2020) examined the digital economy development level of regions in Russia using a functional network. Anyhow, these research studies employed techniques other than artificial intelligence methods and their area of studies are mainly on countries in the Europe region. Despite these quantitative studies,

Charoen (2015), on the other hand, investigated the development of the digital economy in Thailand by only using qualitative study.

These studies underscore the complexity of measuring digital performance and the importance of using multivariate analytical methods. However, they also highlight a critical gap: the lack of indices that integrate multiple dimensions of the digital economy for developing regions like ASEAN.

2.5 Gap in the Literature

Digital integration is imperative for ASEAN's vision to position itself as a global hub for technological advancement and economic growth. However, the persistent digital divide among ASEAN Member States (AMS) threatens to hinder this ambition. While several efforts and frameworks exist to address digital integration, significant gaps remain in the ability to accurately and comprehensively measure digital economy performance in the ASEAN region. These gaps form the foundation and motivation for this study.

i. Limited Research on Digitalization Measurement for AMS

Existing research on the level of digitalization, particularly for ASEAN Member States, remains sparse and fragmented. While global indices such as the World Bank's Digital Adoption Index (DAI), the International Digital Economy and Society Index (I-DESI), and the Digital Economy and Society Index (DESI) provide useful benchmarks, they have several shortcomings when applied to ASEAN economies:

- a. These indices are designed with a global or regional focus (e.g., Europe for DESI), making them less adaptable to the unique economic and infrastructural diversity of ASEAN.

- b. They fail to address country-specific dimensions of digital development, such as institutional support, digital affordability, and infrastructure gaps that are particularly significant in ASEAN's context.

- ii. Strengths and Shortcomings of the ASEAN Digital Integration Index (ADII)

The ASEAN Digital Integration Index (ADII), published in 2021, marks a significant step in measuring digital integration within the region. However, the ADII primarily focuses on the dynamic process of reducing the digital divide, referred to as digital integration. While the ADII highlights efforts to bridge gaps in digital adoption and connectivity, it exhibits several key shortcomings:

- a. Lack of a Comprehensive Performance Measure:

The ADII does not provide a quantifiable and holistic measure of digital economy performance. It emphasizes integration efforts but fails to evaluate economic outcomes, digital adoption across sectors, and the resulting performance gains.

- b. Narrow Scope of Indicators:

The ADII focuses more on closing the digital divide but lacks indicators that capture the breadth of economic digitalization, such as the adoption of digital platforms, e-commerce, digital payment systems, and human capital readiness for digital transformation.

- c. Absence of Comparative Analysis:

The ADII does not offer a clear mechanism for comparing AMS at individual or aggregate levels. Comparative analysis, including clustering of AMS based on their digital economy performance, is essential to understand relative positions, identify leaders, and pinpoint lagging countries.

iii. Research Gaps in Existing Studies

While several studies exist on digital economy development, they tend to suffer from the following limitations:

a. Lack of Focus on ASEAN:

Existing studies often focus on broader global trends (Author, Year) or success stories like China and India (Author, Year), which have different socio-economic contexts compared to ASEAN. The unique challenges faced by AMS—such as the digital infrastructure gap, affordability issues, and disparities in human capital—are insufficiently addressed in the current literature.

b. Fragmented Focus on Individual Indicators:

Many studies analyze isolated aspects of digitalization, such as internet connectivity, ICT investment, or digital literacy (Author, Year), but fail to integrate these indicators into a unified performance framework. The need for a multidimensional and aggregated measure of digital economy performance that reflects connectivity, human capital, and economic utilization is unmet.

c. Lack of Objective Indicator Weighting Methods:

Existing indices often rely on subjective weighting methods, which introduce biases. Objective methods like the Entropy Weight Method (EWM), which is used in this study, are rarely applied to digital economy indices.

iv. Motivation for the Current Study

Given the above gaps, this study is motivated to construct a Digital Economy Performance Indicator (DEPI) tailored specifically for AMS. The DEPI is designed to overcome the limitations of existing indices like the ADII and global measures by:

a. Providing a Comprehensive Measurement Framework:

The DEPI integrates key dimensions such as connectivity, human capital, affordability, and digital adoption into a multidimensional index, offering a complete view of digital economy performance.

b. Filling the Gap in Comparative Analysis:

The DEPI enables intra-country (within-country) analysis by identifying each country's digital strengths and weaknesses across dimensions.

It also supports inter-country (comparative) analysis by clustering AMS based on their digital economy performance, facilitating benchmarking and regional collaboration.

c. Adopting an Objective Methodology:

This study applies the Entropy Weight Method (EWM) to assign indicator weights objectively, eliminating the biases associated with subjective methods used in previous studies.

d. Targeting ASEAN's Digital Ambitions:

As Southeast Asia aspires to become one of the top five digital economies globally by 2025, an accurate and reliable metric like the DEPI is essential to monitor progress, guide policy, and support the region's digital transformation agenda.

In short, this study addresses critical research gaps by developing a Digital Economy Performance Indicator (DEPI) tailored for ASEAN Member States. Unlike existing indices and previous research, the DEPI:

- i. Provides a comprehensive measure of digital economy performance.
- ii. Identifies individual and aggregate performance levels of AMS.
- iii. Offers comparative analysis for benchmarking and regional collaboration.
- iv. Utilizes an objective methodology (EWM) to enhance reliability.

By filling these gaps, the study contributes significantly to the literature on digital economy measurement and provides a practical tool for policymakers to reduce the digital divide, promote digital inclusion, and drive ASEAN's progress toward becoming a global leader in the digital economy.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The previous chapter reviewed various digital-related studies and revealed a gap in the existing measurement tools for assessing the performance of ASEAN member states (AMS) in the digital realm. To address this gap, this chapter outlines the steps and procedures involved in constructing the Digital Economy Performance Indicator (DEPI) for the Southeast Asia region. The remainder of this chapter is organized as follows: Section 3.2 presents the conceptual framework, Section 3.3 outlines the DEPI structure adopted in this study, Section 3.4 discusses methodological considerations for analysis, and finally, Section 3.5 concludes with remarks on the chapter.

3.2 Flow of Constructing DEPI

The components or foundational elements of the digital economy can be assessed through the examination of both supply and demand factors. Statistical tools for measurement may encompass these conceptual domains. As per the OECD (2018), the fundamental building blocks of the digital economy comprise digital data, digital technologies, and digital infrastructure.

In fact, digital economy could be sourced through many dimensions ranging from technical infrastructure to intangible factors such as quality of human capital and habits of society (Balcerzak, 2017) that involving different dimensions. This study will be paying regional attention to AMS which include Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. In measuring the level of digital economy, the dimensions used by European

Commission were studied and after studying, the digital background of ASEAN region, five major dimensions have been identified: connectivity, infrastructure, affordability, human capital, and digital integration of technology. Annual data for 36 variables from 2017 to 2021 are used in the analysis. This sample period is chosen mainly due to data availability and maintain the data coherency across ten countries. Data updates will be carried out from time-to-time when the data is updated and available.

In order to track and monitor the digitalisation level of member states, the European Commission has launched the Digital Economy and Society Index (DESI) initiative since 2014, and publishes a public report every year. DESI discusses the country profiles of all EU Member States from a dynamic perspective, supporting them in identifying priority areas that require attention, and taking important policy actions and decisions to leverage their digital resources. This approach and EU's experience in the digital economy and connectivity have aroused high interest in ASEAN. Following the statement of ASEAN (2022), one of the mutually agreed cooperations between ASEAN and EU is to jointly implement the ASEAN Digital Masterplan (ADM) 2025 and the measurement of digital economy for AMS through the formulation of the ASEAN Digital Index (ADIX). In ADM 2025, they formulate eight desired outcomes that this study carefully aligned with the pre-set outcomes during the screening and selection of datasets aim at constructing DEPI. The eight desired outcomes which this study takes into account in the concept of constructing DEPI are summarised in Figure 3.1.

With the top priority on ASEAN's recovery from COVID-19 as stated in DO1, the rest of seven desired outcomes are specified in order to achieve three aspects: 1) enabling digital inclusion of AMS in the region; 2) growing and strengthening digital services within and between AMS; and 3) increasing productivity and economic growth of AMS. With these

three aspects been achieved, ASEAN can develop into a leading digital community and economic bloc, supported by secure and transformative digital services, technologies and ecosystems. Figure 3.1 illustrates the entire concept of achieving the ADM 2025 vision.

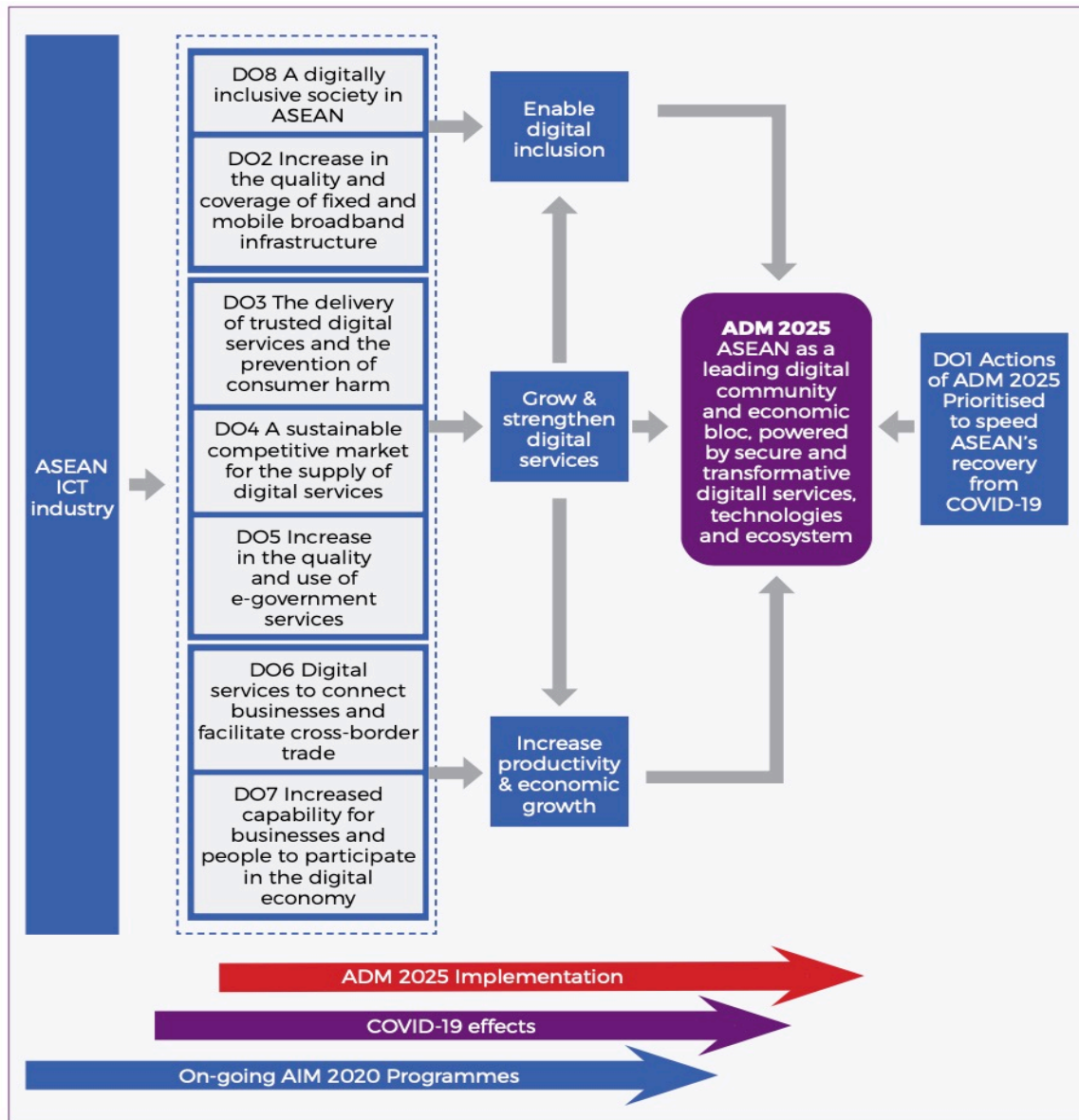


Figure 3.1: ADM 2025

Adopted from ASEAN Digital Masterplan 2025, pg. 7

Following the concepts of OECD building block of digital economy, the DESI framework by EU, and the desired outcomes targeted by ADM, this flow of constructing DEPI for AMS as shown in Figure 3.2.

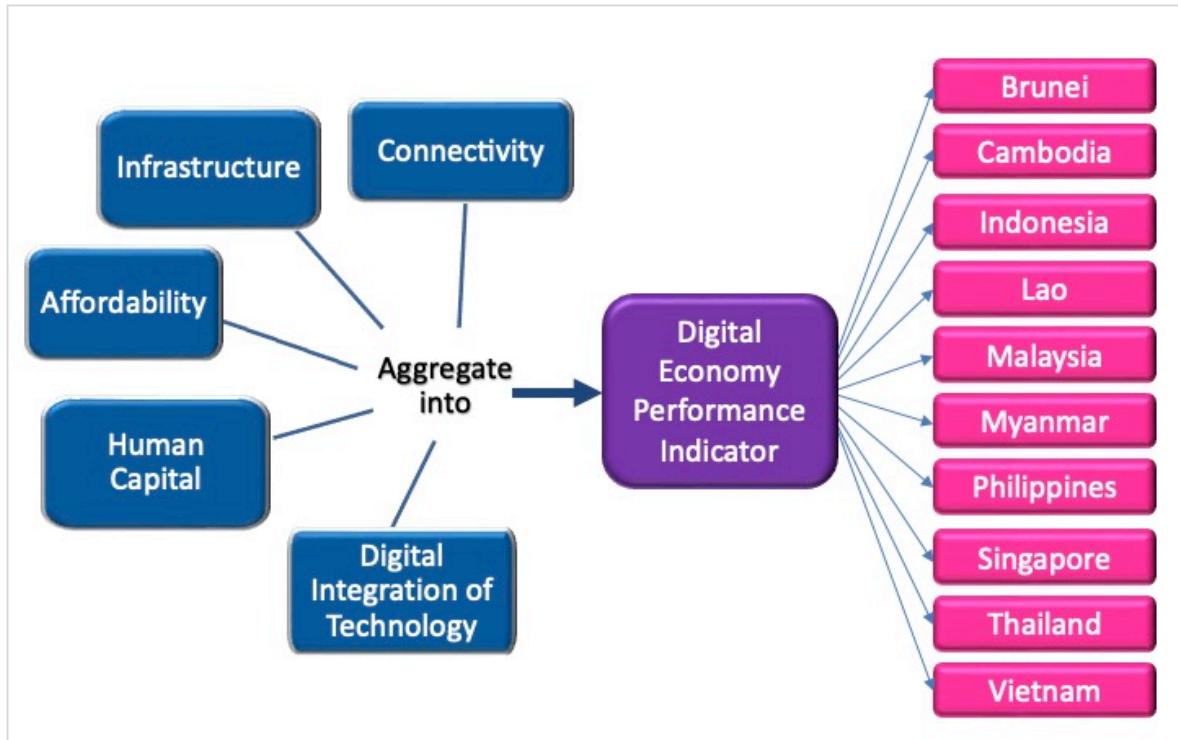


Figure 3.2: Flow of Constructing DEPI

3.3 Structure of DEPI

The Digital Economy Performance Indicator (DEPI) measures AMS's progress towards a digital economy. DEPI therefore brings together a relevant set of indicators for AMS's current digital policy portfolio. The DEPI is developed based on the guidelines and recommendations in the OECD (2008). The data collected range from International Telecommunication Union, World Bank, GSMA Intelligence, UNESCO, United Nations E-Government Development Database and Statista Market Insights.

3.3.1 Dimension 1: Connectivity

Connectivity is one of the most important aspects that the AMS economies need to overcome and improve in order to narrow the digital development gap. Having a stable connectivity infrastructure is the main criterion to achieve digital economy because without it, operations in other dimensions will not be possible. Besides, the development of connectivity can enhance competitiveness and ultimately achieve the ambitious goals of the AEC. There are three sub-dimensions in this dimension:

- i. Subscriptions: This sub-dimension consists of three elements, where it focuses on the subscription related information of citizens, i.e., subscriptions in fixed telephone, fixed broadband, and mobile-cellular and mobile-broadband.
- ii. Network coverage: This sub-dimension focuses on to which extent is their broadband connection's coverage of network access is used by the citizens. It includes 2G, 3G, and 4G network coverages.
- iii. Network performance: The sub-dimension looks into the performance of mobile broadband on the speed of Internet connections with three elements, i.e., download and upload speeds as well as its latencies.

3.3.2 Dimension 2: Infrastructure

- i. Network transfer: This sub-dimension focuses on the physical setups that affect network transfer, which can be estimated from elements such as international bandwidth, number of secure internet servers, and internet exchange points.
- ii. Spectrum: The sub-dimension looks into the performance of spectrum in bands 1-3GHz and spectrum below 1GHz.

3.3.3 Dimension 3: Affordability

- i. Affordability: This sub-dimension centers on the cost of access for Internet that takes into account the fixed broadband and mobile cellular/broadband subscription charges on monthly basis that user would have to pay for the connection. The four elements are all in percentage of GNI per capita of respective countries.

3.3.4 Dimension 4: Human Capital

Apart from connectivity infrastructure, it is also important to look into the human capital situation in AMS. Users would need to have some basic education level to benefit themselves from using the Internet and leverage much potential from digital society. In fact, there are still education development gap within a country as well as among countries in the Southeast Asia region. This part is one of the difficulties that significantly affect the present study to choose some appropriate education indicators to represent the human capital dimension. Instead of going into details like DESI that use STEM graduates² or identify those specifically with ICT skills, this study follows the construction of NRI, IDI, MCI, Web Index, and GDRI to select the appropriate components. The sub-dimension is divided into two categories:

- i. Readiness: The penetration of Internet users in population will be used to represent the readiness of human capital.
- ii. Education: The education level of human capital in AMS will use the several elements as follow: Adult literacy rate, school life expectancy, mean years of schooling, and enrolment rate.

² STEM graduates refer to those complete their study in the fields of science, technology, engineering and mathematics.

3.3.5 Dimension 5: Digital Integration of Technology

There are a wide range of online activities that users will get involved with once they have the Internet connection, knowledge and skills. Some examples of the online activities include engagement in media, make online transaction as well as the online security, which then make up the sub-dimensions and the elements.

- i. Digital media: It contains digital music, ePublishing, video games, and video-on-demand elements to capture the penetration of digitalisation in media.
- ii. Digital commerce: This consists of two elements, i.e., digital commerce and ICT goods exports.
- iii. Digital health: It estimates the penetration of users in using digital-related app, software or devices for the sake of fitness and well-being as well as monitoring their e-Health.
- iv. Online security: The security in surfing the Internet is always a concern to Internet users. Knowing this importance, thus this study uses the Global Cybersecurity Index as a proxy to tell the online security condition of AMS.
- v. e-Government: It enlightens the impact of digitalisation in government service through the online service index score for e-Government.

3.3.6 Rationale for Selection of Components

To construct a robust Digital Economy Performance Indicator (DEPI) tailored for ASEAN Member States (AMS), the selection of components was guided by existing frameworks, namely the Network Readiness Index (NRI), ICT Development Index (IDI), Mobile Connectivity Index (MCI), Web Index, and Global Digital Readiness Index (GDRI). These frameworks were chosen as they are widely recognized and provide comprehensive insights into the digital economy's core dimensions.

i. Network Readiness Index (NRI)

The NRI, developed by the World Economic Forum (WEF), measures countries' readiness to leverage information and communication technologies (ICTs) for competitiveness and well-being. It comprises four pillars: Technology Infrastructure; People; Governance; and Impact.

From the NRI, the study adopted components related to Connectivity (e.g., broadband penetration, mobile network coverage, and internet speed) because infrastructure readiness is foundational for digital economy development. Human-related indicators, such as digital literacy and ICT skills, were selected to evaluate how equipped the population is to adopt and leverage digital tools.

ii. ICT Development Index (IDI)

The IDI, published by the International Telecommunication Union (ITU), assesses ICT development based on three dimensions: Access (infrastructure and affordability); Usage (adoption of ICT services); Skills (education and literacy); and Rationale for Component Selection.

From the IDI, components such as affordability (e.g., internet cost as a percentage of income) and internet access were included to measure economic access to digital technologies. ICT usage indicators like internet penetration and mobile usage were incorporated to capture the extent of digital adoption.

iii. Mobile Connectivity Index (MCI)

The MCI, developed by GSMA, evaluates mobile connectivity through four key enablers: Infrastructure (network coverage and quality); Affordability (cost of mobile data); Consumer Readiness (skills and awareness); and Content and Services (availability of mobile content and services)

Indicators related to mobile network coverage and affordability of mobile data were selected as they are critical for understanding digital inclusion in AMS, particularly in regions where mobile connectivity dominates. The content and services dimension influenced the inclusion of indicators like e-commerce adoption and digital payment usage, which reflect practical adoption of digital platforms.

iv. Web Index

The Web Index, developed by the World Wide Web Foundation, measures the contribution of the web to social, economic, and political development through four dimensions: Universal Access; Relevant Content; Freedom and Openness; and Empowerment.

Components related to universal access (e.g., internet penetration rates and ICT infrastructure) were selected as they align with the study's focus on digital connectivity. Indicators capturing empowerment through digital adoption, such as e-governance usage and digital services, were incorporated to evaluate how AMS leverage digital platforms for public services.

v. Global Digital Readiness Index (GDRI)

The GDRI, developed by Cisco, assesses countries' digital readiness based on seven dimensions: Basic Needs (infrastructure and access); Human Capital (digital skills); Ease of Doing Business; Technology Adoption; Governance and Regulation; Start-up Environment; and Economic Impact.

Components related to human capital (e.g., ICT skills and education levels) were adopted as they are critical for determining a country's readiness for digital transformation. Indicators like technology adoption (e.g., digital payment systems, mobile services) were selected to measure how deeply digital technologies are integrated into economies.

In short, the selection of components based on the NRI, IDI, MCI, Web Index, and GDRI ensures that the proposed DEPI:

- a. Covers multiple dimensions: It captures critical aspects such as infrastructure (connectivity), affordability, digital adoption, and human capital readiness.
- b. Ensures regional relevance: The selected indicators are relevant to ASEAN Member States, which vary in digital infrastructure and development levels.
- c. Addresses existing gaps: While existing indices provide valuable insights, they lack a tailored focus on ASEAN economies. The DEPI combines relevant components to bridge this gap.
- d. Uses established indicators: Aligning with internationally recognized frameworks ensures that the DEPI is credible and comparable to existing indices.

Table 3.1: DEPI Structure

Constraint Layer	Criteria Layer	Indicator Layer	Unit	Source
Dimension	Sub-Dimension	Element		
Connectivity	Subscription	Fixed-telephone subscriptions	Per 100 inhabitants	ITU
		Fixed-broadband subscriptions	Per 100 inhabitants	ITU
		Mobile-cellular subscriptions	Per 100 inhabitants	ITU
		Mobile-broadband subscriptions	Per 100 inhabitants	ITU
	Network Coverage	2G Population Coverage	Population, %	GSMA Intelligence
		3G Population Coverage	Population, %	GSMA Intelligence
		4G Population Coverage	Population, %	GSMA Intelligence
	Network Performance	Average mobile broadband download speeds	%	Ookla's Speedtest Intelligence
		Average mobile broadband upload speeds	%	Ookla's Speedtest Intelligence
		Average mobile broadband latencies	%	Ookla's Speedtest Intelligence
Infrastructure	Network Transfer	International bandwidth per Internet user	kbit/s	ITU
		Number of secure internet servers	Per 1 million people	ITU
		Internet Exchange Points (IXPs)	Per 10 million people	ITU
	Spectrum	Spectrum in bands 1-3GHz	%	100
		Other spectrum below 1GHz	%	100

Table 3.1 continued

Constraint Layer	Criteria Layer	Indicator Layer	Unit	Source
Dimension	Sub-Dimension	Element		
Affordability	Price Basket	Fixed-broadband basket	USD	ITU
		Data-only Mobile-broadband Basket	USD	ITU
		Mobile-cellular low-usage basket	USD	ITU
		Mobile data and voice low-consumption basket	USD	ITU
		Mobile data and voice high-consumption basket	USD	ITU
Human Capital	Accessibility	Individuals using the Internet	Population, %	ITU
		Mobile Ownership	Population, %	GSMA Intelligence
	Education	Adult literacy rate	Population, %	UNESCO Institute for Statistics Data Centre
		School life expectancy	Population, %	UNESCO Institute for Statistics Data Centre
		Mean years of schooling	Population, %	UNESCO Institute for Statistics Data Centre
		Tertiary enrollment	Population, %	UNESCO Institute for Statistics Data Centre

Table 3.1 continued

Constraint Layer	Criteria Layer	Indicator Layer	Unit	Source
Dimension	Sub-Dimension	Element		
Digital Integration of Technology	Digital Media	Digital Music	Penetration rate, %	Statista Market Insights
		ePublishing	Penetration rate, %	Statista Market Insights
		Video Games	Penetration rate, %	Statista Market Insights
		Video-on-Demand	Penetration rate, %	Statista Market Insights
	Digital Commerce	Digital Commerce	Penetration rate, %	April 2023- Digital Commerce
		ICT goods exports	% of Total Goods Exports	World Bank
	Digital Health	Users in Digital Fitness & Well-Being	Penetration rate, %	Statista Market Insights
		Users in e-Health	Penetration rate, %	Statista Market Insights
	Online Security	ITU Global Cybersecurity Index	Score out of 100	ITU
	e-Government	Online Service Index score for E-Government	Score out of 100	United Nations

3.4 Similarity and Dissimilarity between DEPI and I-DESI

While both indices share a common foundation in evaluating digital economy performance across key dimensions, the DEPI prioritizes affordability, mobile-based adoption, and foundational digital skills, which are critical for the ASEAN region. In contrast, the I-DESI focuses on advanced infrastructure, enterprise-level digitalization, and high-quality digital services, reflecting the priorities of more developed economies. By addressing the unique digital challenges of AMS, the DEPI offers a more relevant and actionable tool for guiding digital transformation and reducing the digital divide in ASEAN.

Table 3.2: Similarities and Dissimilarities of Indicators between DEPI and I-DESI

Dimension	Similarities	Dissimilarities
Connectivity	- Both DEPI and I-DESI include indicators for measuring broadband penetration and internet access to reflect infrastructure readiness.	- DEPI places greater emphasis on mobile connectivity (e.g., mobile network coverage and mobile broadband penetration), which is particularly significant for ASEAN Member States (AMS), where mobile technology dominates internet access.
		- I-DESI gives more weight to fixed broadband subscriptions and high-speed fiber connections, which are priorities in developed economies.
Human Capital	- Both indices include digital literacy and ICT skills to measure workforce readiness for digital transformation.	- DEPI emphasizes basic ICT skills and education levels as critical for digital adoption in AMS, reflecting the need to build foundational capabilities.
		- I-DESI focuses on advanced ICT skills such as programming and STEM graduates, which are more relevant for highly digitalized economies.

Table 3.2 continued

Affordability	- Both indices assess the cost of internet access and affordability of digital services.	- DEPI includes affordability indicators tailored to lower-income settings, such as internet cost as a percentage of income, which is a major barrier in AMS.
		- I-DESI prioritizes affordability from a cost-efficiency perspective, such as pricing relative to broadband speed or performance.
Digital Adoption	- Both indices measure indicators related to e-commerce penetration and digital payment usage to reflect digital economic activities.	- DEPI includes mobile-based digital adoption (e.g., mobile payments, mobile e-commerce), which are more prevalent in ASEAN economies due to high mobile usage rates.
		- I-DESI focuses more on business digitalization indicators such as adoption of enterprise resource planning (ERP) systems, cloud computing, and online presence of businesses.
Digital Public Services	- Both indices include e-government adoption and access to digital public services as key indicators for measuring the effectiveness of digitalization in governance.	- DEPI expands the focus to measure the reach and inclusiveness of e-government services, particularly in rural and underserved regions.
		- I-DESI focuses more on the quality and sophistication of digital public services in developed economies, such as the use of advanced e-health systems and digital tax services.

3.5 Methodological Considerations

To construct the DEPI, the present study relies on existing and retrievable data.

3.5.1 Selection Criteria

The selection of data follows the criteria or requirement such as it:

- i. Must be collected on a regular basis. As to monitor the DEPI from time to time, the data used has to be collected ideally on a yearly basis (or at least with a pre-defined regularity).
- ii. Shall be related to the area of interest or direction of development in ASEAN's policies.
- iii. Shall avoid redundancy. The DEPI to be constructed shall not choose or contain redundant elements, either statistically or in terms of interpretation.

3.5.2 Data Updates

Updates and corrections are very common in the lifecycle and nature of statistical data. It is normal if the values of a variable experience some amendments and only being completely stabilised after months or years, since the indicator was originally computed. The DEPI is proposed to construct annually, while there might have some new elements only appear in later years. If there is any newly updated data come out, this study will try to adopt the new data into the construction of DEPI for those particular years. This idea serves as a consideration and guidance because currently this study does not face this issue, although some of the organisations have this issue in the construction of their indices.

The DEPI is composed of five major dimensions, each with respective sub-dimensions and elements. This study aims to remain the structure of DEPI same as those of the DESI by European commission. But due to the different level in economic development and digitalisation, as well as limited data availability (too many data series are not available in AMS), some elements have been replaced with those that better fit for ASEAN digital condition. In selecting appropriate elements, this study follows these procedures (in order):

- i. First try to find the similar data series;
- ii. Look for the feasibility of a proxy-indicator; and
- iii. Choose data series that is better fit for ASEAN digital development level.

3.5.3 Data Treatment

Following the criteria for selection and updating of data, this study ultimately opts for a sample spanning from 2017 to 2021 across all ten AMS. To ensure the objectivity of evaluation outcomes, the selection of assessment indicators adheres to specific principles outlined by Sun (2017):

- i. Principle of consistency: Variables need to be consistent and in line with particular objectives. The content within all variables should be the primary concern for decision-makers during evaluations, serving as the principal criterion for assessing performance levels. Hence, the selected variables should accurately reflect the attainable level of information; and
- ii. Principle of feasibility: The chosen variables must be transparent and comprehensible. For qualitative indices, the scoring criteria should be well-defined, while quantitative indices should rely on easily obtainable data. Qualitative indices are non-numeric measures that capture subjective or descriptive aspects of digital economy performance. These indices are often derived from surveys, expert assessments, or policy evaluations. Examples of qualitative indices in the study might include: Online service index score for e-government that measures the quality and availability of online government services; Global cybersecurity index that assesses the level of cybersecurity readiness in a country; Adult literacy rates where based on surveys or expert assessments of the population's ability to read and write.

Additionally, existing methods or models should be applicable to address the issue at hand.

Once the sample size is determined, the subsequent step involves addressing any outliers and missing data within the sample. Outliers have the potential to distort the index scores' results. For instance, if a country exhibits significantly lower download speeds compared to others, it may receive an exceptionally low score, thereby potentially influencing other countries' scores to appear relatively higher with minimal variation. To detect outliers, indicators are assessed to ascertain if their absolute skewness exceeds 2 and if their kurtosis surpasses 3.5, employing the following formulas:

$$\text{Skewness} = \frac{\sum_{j=1}^m (Y_j - \bar{Y})^3 / m}{s^3} \quad \text{Equation 3.1}$$

$$\text{Kurtosis} = \frac{\sum_{j=1}^m (Y_j - \bar{Y})^4 / m}{s^4} \quad \text{Equation 3.2}$$

where j represents yearly sample by country, $j=1, 2, 3, \dots, m$; Y_j is the value in j th sample; $\bar{Y}$ is the mean of Y_j ; and s is the standard deviation of Y_j .

If the threshold is met, one of the two treatments is applied:

- i. **Winsorisation:** Winsorisation is a method utilized to address outliers by substituting them with less extreme values. It involves adjusting outlier variables by trimming them to their nearest values until the indicator falls within the specified range of skewness and kurtosis. For instance, in this study, the indicator "fixed telephone subscriptions per 100 inhabitants" exhibits an outlier value of 10.3, whereas the next highest value is 4.2. Consequently, the outlier value is replaced with 4.2. This process is iterated until the indicator aligns with the specified range of skewness and kurtosis, with up to six observations being adjusted to prevent excessive modification of the dataset. If this method proves insufficient in reducing skewness and kurtosis, alternative approaches are considered.

- ii. **Transformation:** Given that indicators with higher skewness and kurtosis often exhibit right skewness, a logarithmic transformation is applied to normalize these indicators within the desired range. Despite the "International bandwidth per user (kbit/s)" metric not surpassing the skewness and kurtosis thresholds, it undergoes log-transformation. This adjustment is warranted due to its comparatively larger value, such as 119,998.43 kbit/s, which logarithmic transformation helps bring closer to other values.

3.5.4 Imputation of Missing Observation

If there is any case that some countries have missing observation in certain variables, values for those missing observations can be estimated using the following ways:

- i. using data point that is available from the previous year;
- ii. using data point that is available from the following year;
- iii. using proxy variable to replace the data series.

At present, there is about 2.13 per cent of missing values from the whole dataset is imputed using the above three approaches.

3.5.5 Normalisation

Normalisation has to be done before aggregating all components into a single indicator. This is because the elements chosen have different natures, scales, and units of measurement. There might also have variables with opposite orientation. For example, high broadband price means less people can afford to subscribe broadband, and this does not seem to be good to expand connectivity infrastructure. In this sense, min-max method will be used to normalise the data onto a scale between zero to unity (0-1) using the formula as follows:

$$R_{ij} = \frac{x_{ij} - \min_j(x_{ij})}{\max_j(x_{ij}) - \min_j(x_{ij})} \quad \text{Equation 3.3}$$

$$R_{ij} = \frac{\max_j(x_{ij}) - x_{ij}}{\max_j(x_{ij}) - \min_j(x_{ij})} \quad \text{Equation 3.4}$$

where R_{ij} is the normalised min-max value; i is the variable, where $i=1, 2, 3, \dots, n$; x_{ij} is the original value at i th variable and j th sample; $\min_j(x_{ij})$ is the minimum value of the i th variable; and $\max_j(x_{ij})$ is the maximum value of the i th variable.

For variables with positive direction (i.e., where higher is better), it is normalised using the Eq. 3.3. Notably for variables with negative direction towards DEPI, the normalised scale should be the other way round using the Eq. 3.4. The 0 value in the normalised scale is anchored to the minimum value in the variable's original scale, and the value 1 is anchored to the maximum value.

3.5.6 Determining Weights of Different Variables based on Entropy

Before determining the indicators, this study established the weights of the indicators using a specific approach. It's essential to have a systematic method for evaluating spatial and temporal progress in sustainable development, and determining indicator weights is a crucial aspect of this process. Existing literature highlights several methods for calculating weights. The equal weighting method, employed by Van de Kerk and Manuel (2008), is the simplest and most straightforward approach, but it may lack objectivity in its results. To obtain objective weights, scholars have developed methods such as principal component analysis (Perez et al., 2013) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method (Deng and Yeh, 2000). Additionally, the entropy weight coefficient method is widely used (e.g., Shemshadi et al., 2011; Wang et al., 2015; Ding et al., 2016; Gao et al., 2019; Wang et al., 2020; Zhu et al., 2020; and Xu & Li, 2022).

This study adopts the entropy weight coefficient method to determine the weights of different indicators for several reasons. Firstly, entropy serves as a measure of uncertain information, with its magnitude inversely proportional to the amount of information present. Lower entropy values indicate greater information content and weight. Utilizing data-driven calculations for weight determination helps mitigate the influence of human biases on index weights, thus enhancing the objectivity of comprehensive evaluation outcomes (Zhu et al., 2020). Secondly, the entropy weight coefficient method is widely accepted due to its reliance on data from the dataset itself and its relatively straightforward computational process. Originating from information theory, entropy elucidates information or uncertainty (Shannon, 1949; Shannon & Weaver, 1949; Li et al., 2016; Gao et al., 2018) and finds applications in diverse fields such as water quality assessment, engineering, economics, among others (Zou et al., 2016). Its utilization extends to regional development as well (Shen et al., 2015). As confirmed by Shemshadi et al. (2011), the entropy weight coefficient method is suitable for calculating weights for a set of indicators and evaluating development performance. The application of the entropy weight coefficient method typically involves three steps, as illustrated in various studies including those by Shen et al. (2015), Zheng et al. (2017), and Gao et al. (2020).

Step 1: After normalization, calculate the proportion of R_{ij} , divided by the sum of R_{ij} , as follows:

$$f_{ij} = \frac{R_{ij}}{\sum_j^m R_{ij}} \quad \text{Equation 3.5}$$

Step 2: According to the value of f_{ij} , the formula of the entropy value is written as follows, where h_i represents the value of the entropy of each variable:

$$h_i = -k \sum_j^m f_{ij} \times \ln(f_{ij}) \quad \text{Equation 3.6}$$

$$k = \frac{1}{\ln(m)} \quad \text{Equation 3.7}$$

Step 3: Next, according to the value of entropy among the indicators, now the weight ω_i of i th variable can be determined as such:

$$\omega_i = \frac{1 - h_i}{\sum_i^n (1 - h_i)} \quad \text{Equation 3.8}$$

This method ensures that the weightage of each dimension in DEPI is determined based on objective statistical principles rather than subjective assignments. By computing the variability and significance of each indicator, the most influential dimensions receive greater weight, ensuring that DEPI provides a reliable and comprehensive measure of digital economy performance across AMS. In short, it is meant to ensure that the most influential dimensions contribute more to the overall index while minimizing subjective bias.

3.5.7 Aggregation

Each element, sub-dimension, and dimension will be assigned an index score and then combined into an overall index score, termed as the Digital Economy Performance Indicator (DEPI) in this study. The DEPI can be calculated by applying the weights of the indicators from Equation 3.8 and the standardized values from Equations 3.3 and 3.4. This involves utilizing a weighted sum method, which multiplies the weights by the standardized values and sums the results according to the following formula:

$$DEPI_j = \sum_i^n \omega_i \times R_{ij} \quad \text{Equation 3.8}$$

where $DEPI_j$ represents the performance score of sample j . According to the DEPI structure in Table 3.1, the variables are divided into five dimensions: connectivity(*con*),

infrastructure (*inf*), affordability (*aff*), human capital (*hum*), and digital integration of technology (*dig*). Following Equation 3.8, the dimensional performance can also be calculated as follows:

$$D_{j(con)} = \sum_i^{n_{con}} \omega_{i(con)} \times R_{ij(con)} \quad \text{Equation 3.9}$$

$$D_{j(inf)} = \sum_i^{n_{inf}} \omega_{i(inf)} \times R_{ij(inf)} \quad \text{Equation 3.10}$$

$$D_{j(aff)} = \sum_i^{n_{aff}} \omega_{i(aff)} \times R_{ij(aff)} \quad \text{Equation 3.11}$$

$$D_{j(hum)} = \sum_i^{n_{hum}} \omega_{i(hum)} \times R_{ij(hum)} \quad \text{Equation 3.12}$$

$$D_{j(dig)} = \sum_i^{n_{dig}} \omega_{i(dig)} \times R_{ij(dig)} \quad \text{Equation 3.13}$$

where D_j represents the total dimensional score of each dimension, n_{con} , n_{inf} , n_{aff} , n_{hum} , and n_{dig} represent the number of variables in each dimension.

Figure 3.3 illustrates the steps of constructing the DEPI for AMS.

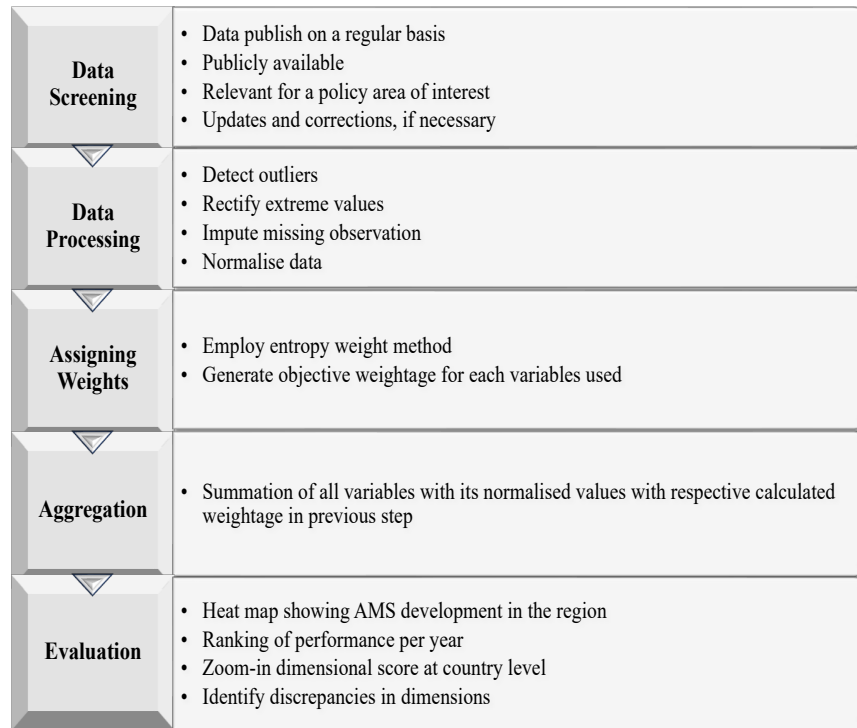


Figure 3.3: Process Flow of Evaluation Index System

3.5.8 Rationale of Using Entropy Weight Method (EWM) as Weighting Approach

The Entropy Weight Method (EWM) is used to determine the weight of each indicator based on its information contribution. This method is appropriate because:

- i. **Objective and Data-Driven:** Unlike subjective methods (e.g., expert-based weighting), EWM eliminates bias by assigning weights based on data variability.
- ii. **Dynamic Weighting:** EWM automatically adjusts weights depending on the importance of each indicator in explaining differences among AMS.
- iii. **Suitable for Multi-Dimensional Indices:** It allows for a fair comparison across countries with varying levels of digital development.

By contrast, alternative methods like Analytical Hierarchy Process (AHP) were not used because they rely on expert judgment, which can introduce bias and inconsistency.

3.5.9 Classification

To evaluate the extent of digital economy performance, this research categorizes the DEPI values into three tiers based on prior studies such as those conducted by Li et al. (2012) and Shen et al. (2015). These tiers are identified as strong, medium, and weak, as outlined in Table 3.3.

Table 3.3: Value and Level of Development

DEPI Value	Level of Development	Definition & Characteristics
$0.8 \leq \text{DEPI} \leq 1.0$	Strong Development	• Countries with high digital infrastructure readiness, strong ICT penetration, and widespread digital adoption in businesses and public services. • Key Indicators: High broadband penetration, strong mobile network coverage, high digital literacy, strong e-commerce and digital payments adoption.
$0.5 \leq \text{DEPI} < 0.8$	Medium Development	• Countries with moderate ICT infrastructure and growing digital adoption, but still face barriers such as high costs, limited digital literacy, or inconsistent policy implementation. • Key Indicators: Moderate internet penetration, increasing but not universal access to digital financial services, some government e-services but limited full digital transformation.

Table 3.3 continued

DEPI Value	Level of Development	Definition & Characteristics
$0 \leq \text{DEPI} < 0.5$	Weak Development	• Countries with poor digital infrastructure, low digital literacy, and minimal adoption of e-services and e-commerce. • Key Indicators: Low broadband and mobile penetration, high internet costs relative to income, lack of government digital services, limited ICT skills in the workforce.

The Level of Development classification is based on methodologies developed by Li et al. (2012) and Shen et al. (2015), which categorize economies or regions based on their digital infrastructure, adoption rates, and economic integration of digital technologies. These studies provide a structured approach to grouping countries into different levels of digital development by analyzing key performance indicators. This is carefully done and selected due to several factors as follow:

- i. **Data-Driven Categorization:** Both studies use quantitative thresholds rather than arbitrary classifications, ensuring that countries are grouped based on their actual digital performance rather than subjective assessment.
- ii. **Comprehensive Multi-Dimensional Approach:** Their framework evaluates multiple dimensions such as connectivity, digital adoption, affordability, and human capital, aligning with the Digital Economy Performance Indicator (DEPI) used in this study.
- iii. **Widely Applied in Digital Economy Research:** Their classification methodology has been referenced in ICT development, digital transformation studies, and policy reports to assess digital readiness in both developed and developing countries.

- iv. Applicable to ASEAN Digital Economy Measurement: ASEAN Member States (AMS) exhibit diverse levels of digital development, making a tiered classification system essential for meaningful comparisons and targeted policy recommendations.

3.6 Robustness Checking

To carry out robustness checking, this study opted for the sensitivity analysis to test how sensitive the Digital Economy Performance Indicator (DEPI) scores are to changes in the weighting method. Specifically, this study compared the results obtained using the entropy weight method (EWM) with those from an equal weighting method. This helped determine whether the findings are robust to different weighting approaches.

- i. Step 1: Recalculate DEPI Scores Using Equal Weighting
 - a. Assign Equal Weights: Instead of using the entropy weights, assign equal weights to all indicators within each dimension. For example, if there are 5 indicators in the connectivity dimension, each indicator will have a weight of 0.20 (1/5).
 - b. Recalculate Dimensional Scores: Use the same normalized data (from the min-max method) but apply equal weights to calculate the dimensional scores.
 - c. Recalculate Aggregated DEPI Scores: Aggregate the equally weighted dimensional scores to obtain the DEPI score for each country.
- ii. Step 2: Compare Results with Entropy-Weighted DEPI Scores
 - a. Rank Countries: Rank the AMS based on their DEPI scores calculated using both the entropy weight method and the equal weighting method.
 - b. Analyze Differences: Compare the rankings and scores from both methods to identify any significant differences. If the rankings remain consistent, this indicates that the findings are robust to changes in the weighting method.

- c. Visualize Results: Create a table or chart to show the DEPI scores and rankings from both methods side by side. Highlight any countries where the rankings differ significantly.

3.7 Chapter Remark

In this study, it is crucial to select appropriate elements and define sub-dimensions that could reveal the digitalisation level of ASEAN economies. At present, this study proposes to construct digital economy performance indicator with a structure of five dimensions, 12 sub-dimensions, and 36 elements. Next, the methodology considerations are also essential to treat the data series carefully. It is because different elements have different scales and ranges and thus a series data treatment is necessary.

In order to meet the specific objectives of this study, appropriate methods will be implemented. The construction of the DEPI follows the common procedures of constructing an index, just as the steps done in constructing DEPI (by European Commission), NRI (WEF/Portulans Institute), DAI (by World Bank), and other aforementioned indices in previous chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter discusses on the empirical findings. Section 4.2 shows the descriptive statistics of dataset used in constructing the DEPI for AMS, Section 4.3 reveals the individual weightages that have been found using the entropy weight method, Section 4.4 entails the DEPI score for AMS across years of study.

4.2 Skewness and Kurtosis Results

After data screening and selection process is done, the first attempt is to check the skewness and kurtosis of the dataset. There are several variables are detected with skewness and kurtosis problems in which the data exceeds the predefined thresholds and thus, this study transforms the affected data using natural logarithm. This treatment is done on 2G population coverage, 3G population coverage, 4G population coverage, average mobile broadband download speeds, international bandwidth, number of secure internet servers, internet exchange points (IXPs), and users in digital fitness & well-being. After treatment, the data is free from the skewness and kurtosis problem. The descriptive statistics of the dataset before normalisation are shown in Table 4.1.

Skewness measures the symmetry of the data distribution. A positive skew indicates a longer right tail (most values are concentrated on the lower end), while a negative skew suggests a longer left tail (most values are concentrated on the higher end). Kurtosis measures the "tailedness" of the distribution. A kurtosis greater than 3 suggests a distribution with heavy tails, while a negative kurtosis indicates a flatter distribution.

Table 4.1: Descriptive Statistics

Variable	Skewness	Kurtosis	Min	Max
Fixed-telephone subscriptions	0.68	-0.91	0.24	34.55
Fixed-broadband subscriptions	0.74	-0.48	0.21	25.69
Mobile-cellular subscriptions	-1.16	1.62	51.55	181.77
Mobile-broadband subscriptions	0.04	-0.92	39.18	154.00
2G Population Coverage	-0.77	-0.87	94.00	100.00
3G Population Coverage	0.51	-0.86	89.98	100.00
4G Population Coverage	-1.70	2.28	60.62	100.00
Average mobile broadband download speeds	0.66	0.01	1.64	4.20
Average mobile broadband upload speeds	0.70	-0.27	9.34	83.27
Average mobile broadband latencies	-1.37	2.44	48.56	92.63
International bandwidth per Internet user	1.26	1.66	9.12	15.82
Number of secure internet servers	0.10	-0.81	2.24	11.76
Internet Exchange Points (IXPs)	0.71	0.01	0.00	4.61
Spectrum in bands 1-3GHz	0.15	-1.00	13.33	93.33
Other spectrum below 1GHz	1.23	0.08	28.57	100.00
Fixed-broadband basket	0.65	-0.14	2.74	36.99
Data-only Mobile-broadband Basket	1.30	1.13	1.05	22.17
Mobile-cellular low-usage basket	0.98	2.06	1.02	17.94
Mobile data and voice low-consumption basket	0.25	-0.73	1.33	17.94
Mobile data and voice high-consumption basket	0.65	-0.21	2.85	32.99
Individuals using the Internet	0.06	-1.24	23.62	98.08
Mobile Ownership	1.27	0.98	46.15	93.86
Adult literacy rate	-1.04	-0.41	80.06	97.59
School life expectancy	0.13	-0.88	31.97	76.03
Mean years of schooling	-0.12	-1.11	26.19	80.95
Tertiary enrollment	1.38	1.67	13.13	91.09
Digital Music	1.33	2.82	1.00	35.79
ePublishing	-0.18	-0.59	3.80	22.70
Video Games	0.15	-1.32	7.20	43.48
Video-on-Demand	0.31	-1.41	15.00	65.70
Digital Commerce	0.00	-0.73	9.90	57.40
ICT goods exports	0.45	-1.36	0.04	50.86
Users in Digital Fitness & Well-Being	1.05	0.39	2.11	24.14
Users in e-Health	0.97	0.14	4.34	50.48
ITU Global Cybersecurity Index	-0.33	-1.47	16.10	98.52
Online Service Index score for E-Government	-0.41	-1.04	15.04	98.61

The dataset is then normalised using the min-max method and each variable has a minimum value of 0 and maximum value of 1, now that this dataset is comparable and then proceed to the next step. The minimum and maximum values provide an indication of the range of data points, helping to understand the spread of digital economy indicators across AMS. There are several key observations highlighted from Table 4.1:

- i. Connectivity Indicators
 - a. Fixed-telephone subscriptions (Skewness = 0.68, Kurtosis = -0.91): The distribution is moderately skewed to the right, indicating that most AMS have relatively low fixed-telephone penetration, while a few countries have high values.
 - b. Mobile-cellular subscriptions (-1.16, 1.62): Negatively skewed, meaning that a few AMS have extremely high mobile-cellular penetration, while the majority have moderate values.
 - c. 4G Population Coverage (-1.70, 2.28): A significant negative skew suggests that most AMS have achieved near-complete 4G coverage, while a few lag behind.
- ii. Internet and Broadband Indicators
 - a. Average mobile broadband download speeds (0.66, 0.01): Slight positive skew, indicating that a few AMS have significantly higher speeds, while others have lower but relatively stable speeds.
 - b. International bandwidth per internet user (1.26, 1.66): A strong right skew suggests that bandwidth availability varies widely across AMS, with some countries having much lower capacity.
 - c. Number of secure internet servers (0.10, -0.81): Close to symmetric distribution, indicating relatively even availability of secure digital services across AMS.

- iii. Affordability Indicators
 - a. Fixed-broadband basket (0.65, -0.14) and Mobile data and voice baskets (0.65, -0.21): Indicate variations in pricing across AMS, with affordability being a critical issue for lower-income economies.
- iv. Human Capital and Digital Adoption Indicators
 - a. Individuals using the Internet (0.06, -1.24): The low skewness suggests an even distribution, meaning most AMS have moderate levels of internet penetration.
 - b. Adult Literacy Rate (-1.04, -0.41): Negative skew indicates that most AMS have high literacy rates, while only a few have significantly lower levels.
 - c. ICT Goods Exports (0.45, -1.36): Indicates that while ICT exports are a key driver of digital economy growth in some AMS, there is wide variation in contributions across countries.
- v. Digital Public Services and Cybersecurity
 - a. ITU Global Cybersecurity Index (-0.33, -1.47): Suggests that AMS have relatively even cybersecurity readiness, but a few countries are significantly more advanced than others.
 - b. Online Service Index for E-Government (-0.41, -1.04): Indicates varying levels of e-government implementation across AMS, with most countries showing moderate progress.

4.3 Weightage Results of Entropy Evaluation

Following the three steps as stated in section 3.4.6, the Entropy method evaluates the weight of each indicator and Table 4.2 tabulates the outcomes. The table outlines the relative importance of each factor in measuring digital economy performance across ASEAN Member States (AMS).

Table 4.2: Entropy Evaluation of Variables (Weightage)

Variable	ω_i	Variable	ω_i
Fixed-telephone subscriptions	0.054	Individuals using the Internet	0.021
Fixed-broadband subscriptions	0.048	Mobile Ownership	0.044
Mobile-cellular subscriptions	0.011	Adult literacy rate	0.013
Mobile-broadband subscriptions	0.019	School life expectancy	0.025
2G Population Coverage	0.023	Mean years of schooling	0.033
3G Population Coverage	0.060	Tertiary enrollment	0.044
4G Population Coverage	0.011	Digital Music	0.034
Average mobile broadband download speeds	0.023	ePublishing	0.020
Average mobile broadband upload speeds	0.028	Video Games	0.031
Average mobile broadband latencies	0.006	Video-on-Demand	0.030
International bandwidth per Internet user	0.021	Digital Commerce	0.017
Number of secure internet servers	0.025	ICT goods exports	0.062
Internet Exchange Points (IXPs)	0.029	Users in Digital Fitness & Well-Being	0.039
Spectrum in bands 1-3GHz	0.019	Users in e-Health	0.036
Other spectrum below 1GHz	0.057	ITU Global Cybersecurity Index	0.030
Fixed-broadband basket	0.019	Online Service Index score for E-Government	0.024
Data-only Mobile-broadband Basket	0.009		
Mobile-cellular low-usage basket	0.007		
Mobile data and voice low-consumption basket	0.015		
Mobile data and voice high-consumption basket	0.014		

Source: Author's calculation

Connectivity is the prerequisite for digital economy development. Without strong internet access, mobile network coverage, and broadband penetration, other digital transformations cannot take place. High weightage (28%) reflects the critical role of connectivity in determining a country's digital readiness. While infrastructure is a necessary enabler, it is not sufficient alone—digital economy success also depends on adoption and affordability. Moderate weightage (15%) acknowledges that infrastructure quality is important but must be supported by affordability and usage.

Table 4.3: Entropy Evaluation of Variables (Weightage)

Dimension	ω_i	Justification
Connectivity	28%	- Connectivity serves as the backbone of digital transformation, enabling individuals and businesses to access digital services. - This dimension aligns with previous findings by Castells (2010), who emphasized that digital connectivity is a key driver of economic development. Countries with strong connectivity tend to have better economic and social outcomes.
Infrastructure	15%	- Physical and digital infrastructure, such as broadband networks and mobile coverage, are essential for digital economy growth. - According to Koutroumpis (2018), digital infrastructure investment is crucial for sustaining a competitive digital economy. The lower weight assigned may reflect that infrastructure alone does not determine digital readiness but must be complemented by other factors.

Table 4.3 continued

Affordability	6%	• The cost of internet and digital services directly influences accessibility and inclusivity in the digital economy. • As noted by ITU (2019), affordability remains a significant barrier in many developing nations. The relatively low weight suggests that while affordability is essential, it is not the sole determinant of digital inclusion.
Human Capital	18%	• Digital skills, ICT education, and workforce readiness are key drivers of technology adoption. • This finding is supported by research from Katz and Koutroumpis (2014), which states that human capital development plays a vital role in digital adoption and utilization.
Digital Integration of Technology	32%	• The extent to which digital tools, platforms, and innovations are adopted determines the real impact of digital transformation. • This aligns with Brynjolfsson and McAfee (2014), who argue that digital integration significantly influences productivity and innovation, justifying the high weighting assigned.

Although affordability plays a role in digital inclusion, it has lower variability across AMS, meaning it contributes less in distinguishing performance. Low weightage (6%) reflects that while affordability is a barrier, its impact is secondary to connectivity and digital adoption. Skilled individuals drive innovation, digital literacy, and economic competitiveness. Moderate weightage (18%) highlights that human capital is essential for long-term digital transformation. Digital integration of technology measures real-world

digital adoption, which is the ultimate goal of digital economy growth. Highest weightage (32%) reflects that a country's digital economy is measured not just by infrastructure, but by how well businesses and individuals integrate digital solutions.

The next section, 4.4, presents the computed DEPI scores across AMS, analyzing how each country performs based on the weighted aggregation of indicators.

4.4 AMS DEPI Score across Years

With the weightage of each dimension and indicator established in Section 4.3, this section presents the computed DEPI scores for each ASEAN Member State. The final DEPI scores are derived through the weighted aggregation of normalized indicators, reflecting each country's overall digital economy performance. A higher DEPI score indicates a stronger digital economy foundation, while a lower score highlights areas requiring further development. The results are analyzed in detail, providing insights into regional digital disparities and comparative strengths among AMS.

The ASEAN region boasts one of the world's fastest-growing Internet user bases³, with Southeast Asia's digital economy surpassing expectations and projected to reach \$300 billion by 2025. Furthermore, ASEAN benefits from a youthful population, with one-third of its citizens being under 19 years old as of 2019, coupled with high adult literacy rates exceeding 94 percent in most ASEAN countries. These demographic factors are poised to drive digital consumption growth in the foreseeable future. However, notable disparities exist in the economic and social statuses among ASEAN member states, leading to significant discrepancies in the level of digital infrastructure across the region. This variation

³ Southeast Asia's Internet Economy to Cross \$100 Billion This Year: Industry Report, Reuters, 10 November 2022.

is evident in the DEPI scores of AMS from 2017 to 2021, illustrating persistent inter-country disparities over the years.

Singapore has emerged as a key hub for digital infrastructure, boasting a significant presence of submarine cables and a thriving digital economy. The city-state hosts fifteen out of ASEAN's thirty-five "unicorn" companies and actively contributes to shaping global regulations in the digital realm, such as Digital Economic Partnership Agreements (DEPAs). Over the years, Singapore consistently ranks at the forefront among other ASEAN member states, as illustrated in Figures 4.1 to 4.5. On the other hand, Indonesia stands out as a prominent player in the region's e-commerce sector, boasting the largest market share. The ASEAN Leaders' Statement in October 2021 emphasized the critical need to support the digital transformation across all ASEAN nations. In this regard, ASEAN leaders pledged to deepen digital cooperation and enhance cybersecurity measures. Furthermore, all ASEAN countries are committed to enhancing the quality, accessibility, and affordability of digital connectivity within the region⁴.

The ASEAN region encounters several challenges that impede its growth potential. Firstly, there is limited broadband access in rural areas, particularly in countries like Indonesia, Thailand, the Philippines, and Vietnam, where a significant portion of the population resides. This lack of reliable internet connectivity hampers digital development in these areas. Secondly, many consumers in the region, notably in Indonesia, lack sufficient banking services, hindering their ability to engage in online transactions and limiting industry growth. Moreover, there is a general reluctance among ASEAN citizens, except Singaporeans, to share financial information online, which affects online shopping behavior.

⁴ ASEAN Leaders' Statement on Advancing Digital Transformation in ASEAN, ASEAN, October 2021.

Additionally, the regulatory framework in the region is not uniformly applied to local and international businesses, creating disparities that disadvantage local players. For instance, in Malaysia, local businesses are subject to Government Sales Tax (GST) on transactions, while international transactions are not. Similarly, Indonesia imposes high import tariffs on manufactured goods compared to other ASEAN countries. Furthermore, online shopping within ASEAN is subject to varying taxes and duties, complicating cross-border transactions.

Lastly, except for a few countries like Singapore, Malaysia, the Philippines, and Indonesia, many ASEAN member states lack comprehensive digital strategies. Without robust plans to leverage the digital economy, policymakers may overlook these challenges and fail to address them effectively, hindering the region's full potential for growth. Therefore, it is crucial for policymakers to develop comprehensive strategies to address these obstacles and unlock the region's digital potential.

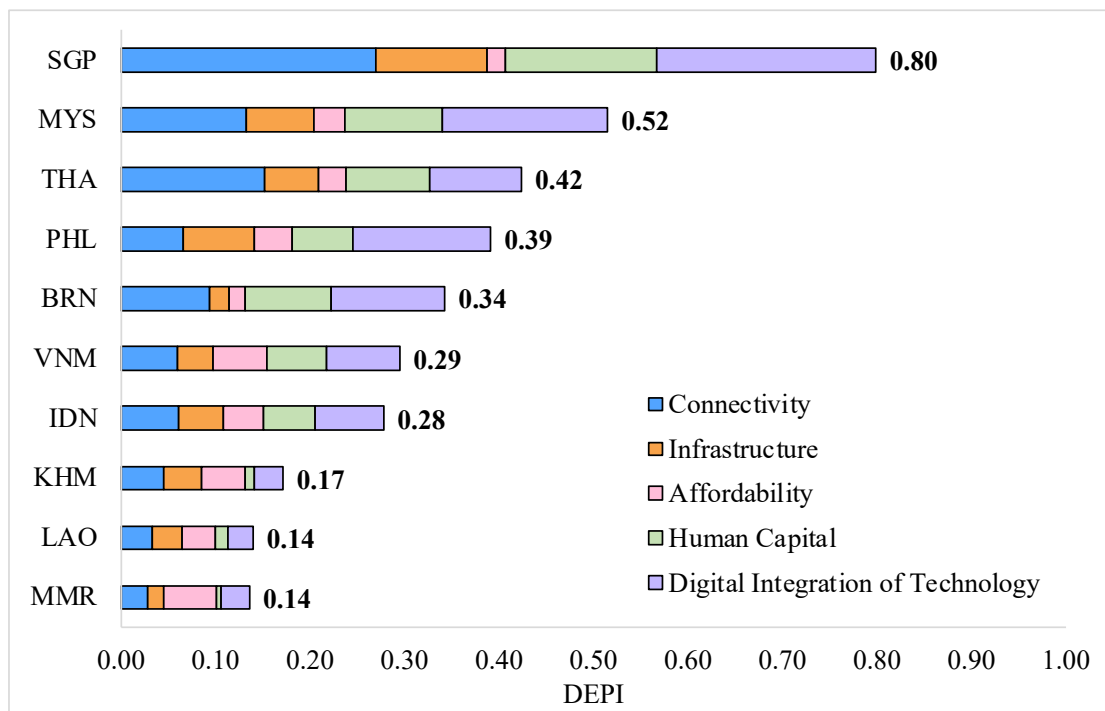


Figure 4.1: AMS DEPI 2017

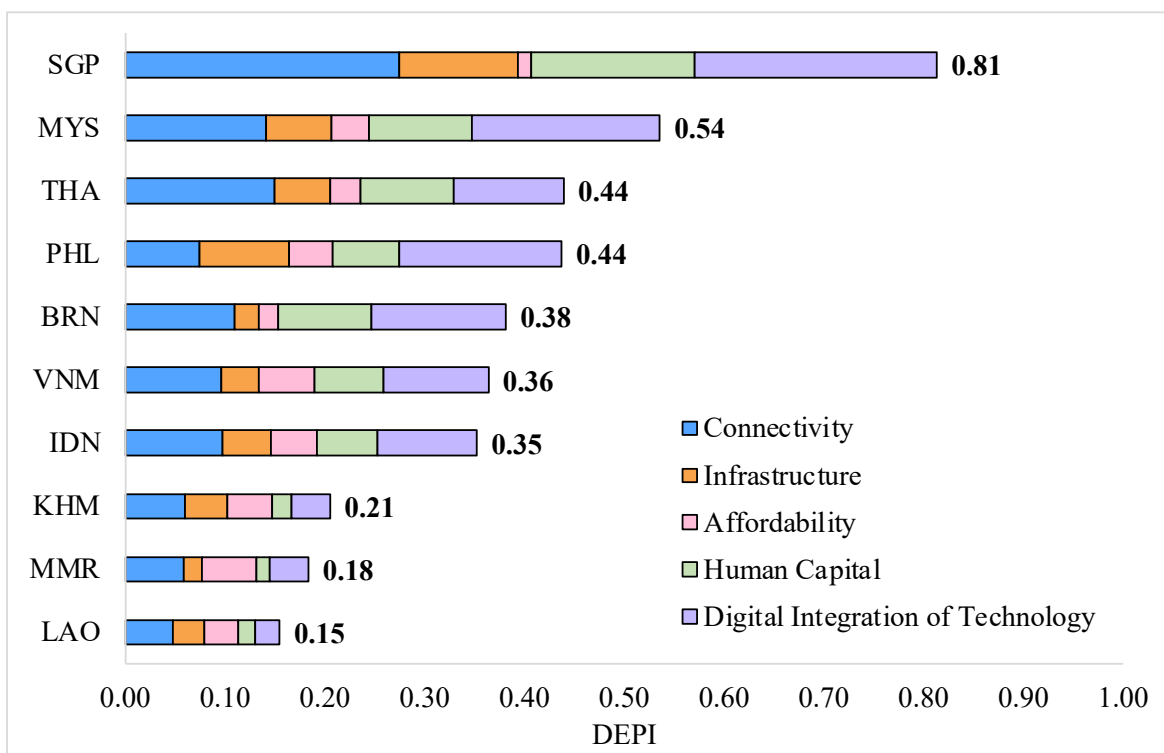


Figure 4.2: AMS DEPI 2018

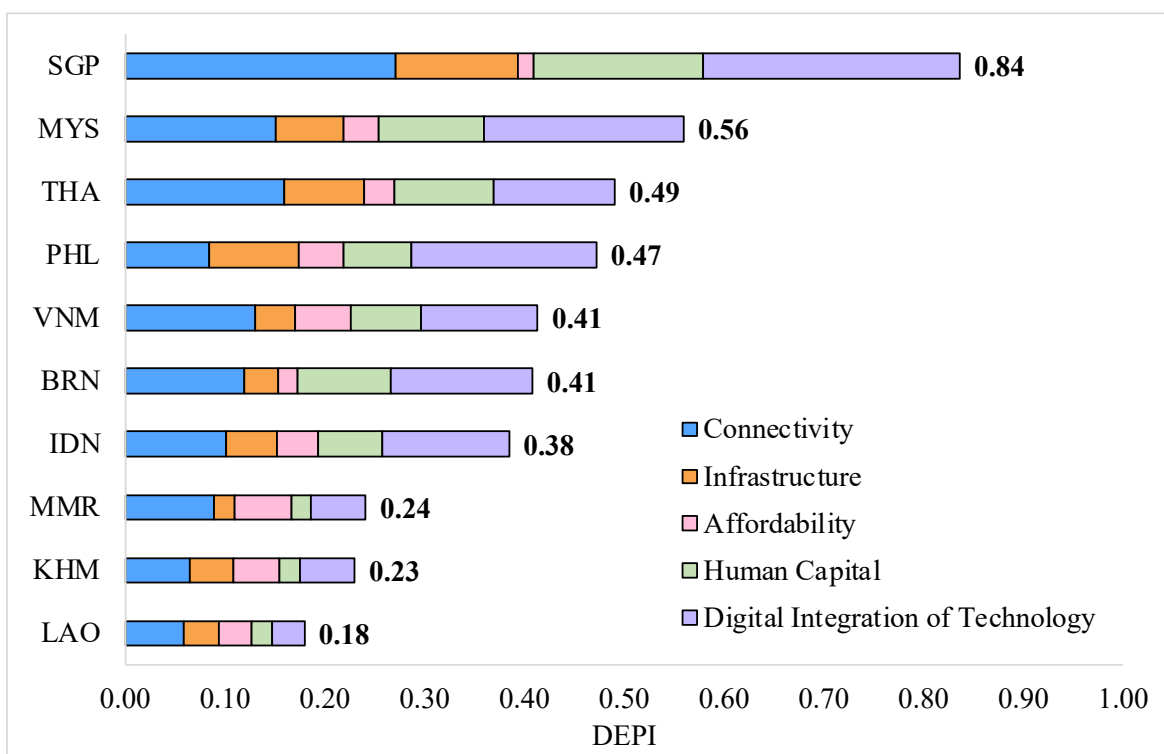


Figure 4.3: AMS DEPI 2019

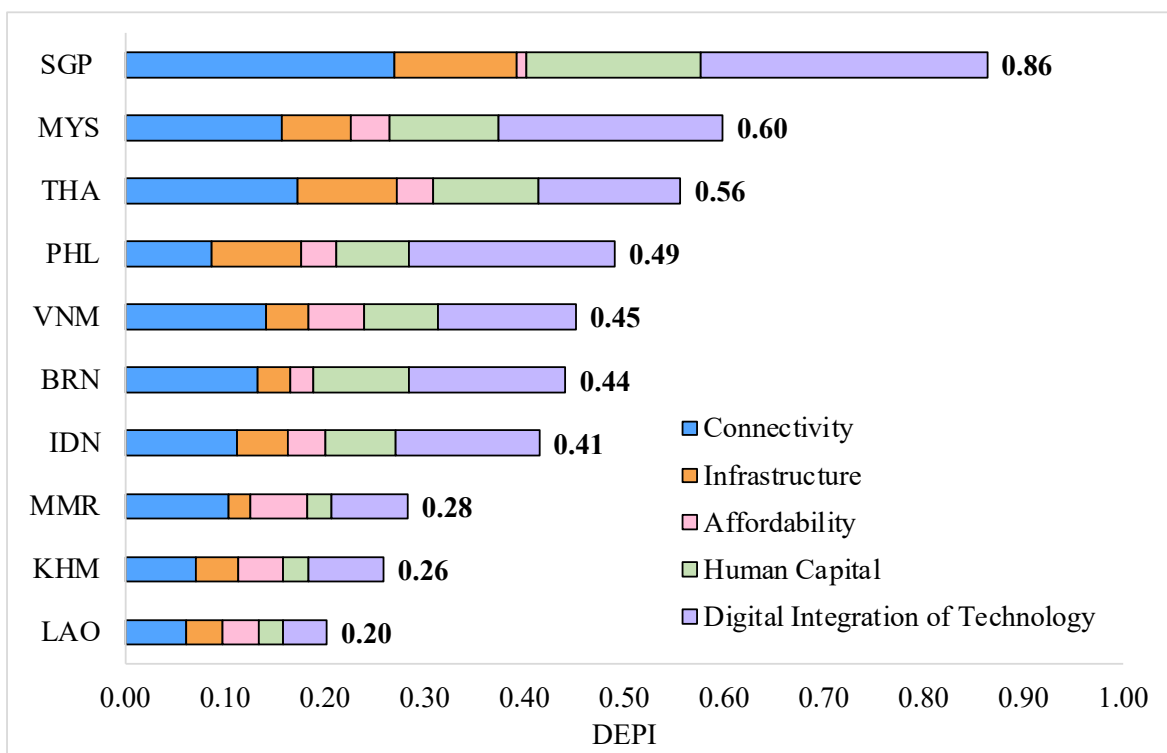


Figure 4.4: AMS DEPI 2020

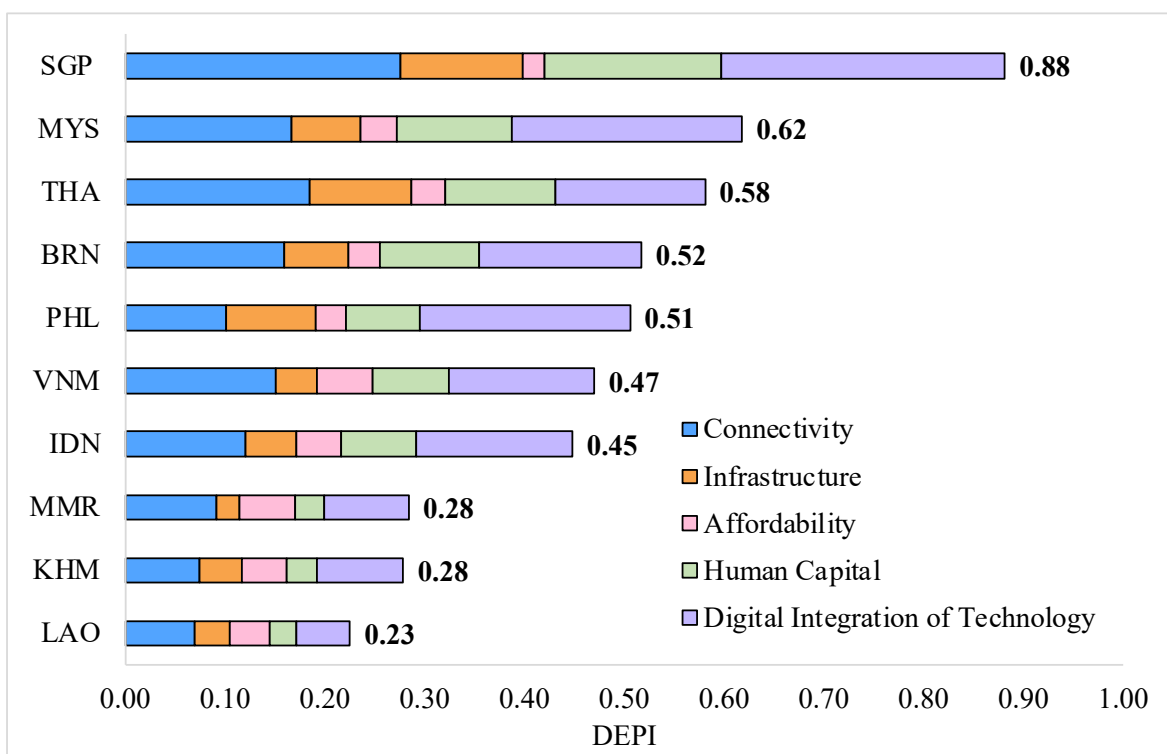


Figure 4.5: AMS DEPI 2021

Policymakers may initiate the formulation of an all-encompassing digital strategy, encompassing both national and regional levels. This strategy could encompass various discussions aimed at addressing challenges on both the supply and demand sides:

Boosting Up Connectivity

Policymakers may prioritize achieving universal broadband access as it serves as the fundamental infrastructure for the optimal functioning of digital technology across various domains. By ensuring stable connections and robust infrastructure capable of providing reliable internet access, there can be a natural enhancement in the environment for investment in digital infrastructure. This, in turn, can contribute to the improvement of digital literacy and the awareness of the advantages offered by a digital society. ASEAN's telecommunications operators have been augmenting their investments in bolstering data traffic and connectivity necessities to swiftly adapt to the fast-paced evolution of digital technology. One potential approach to achieve this could involve allocating an additional 700 MHz of spectrum, which would assist in ensuring that telecommunications operators have the necessary scale to render their investments profitable in the long term. However, addressing the associated costs remains a crucial issue that requires attention. Concurrently, fostering a robust industrial economy is also essential to incentivize operators to invest in infrastructure, particularly in rural areas. Offering incentives to operators who undertake such investments in rural regions could be considered as a means to encourage their involvement.

Nourishing Digital Talent

To ensure a sustainable supply of skilled labor capable of driving digital innovation, ASEAN leaders should adopt a comprehensive policy approach that encompasses various

factors including leadership, workforce development, and intellectual property protection. Several areas within the policy framework could be considered by regional leaders to nurture talent:

Currently, most education systems in the region struggle to keep pace with rapid digital advancements. Teaching methods often fail to resonate with the evolving minds of young learners or align with modern technological trends. Therefore, governments need to overhaul the existing K-12 education system, blending traditional methodologies with a curriculum supported by innovative technologies. Emphasis should be placed on imparting skills such as critical thinking, problem-solving, digital literacy, creativity, and the development of emotional and social competencies.

Additionally, there's an opportunity to expand the existing talent pool immediately. Given the shortage of technical graduates in the region, governments could offer financial incentives, tax benefits, or other enticements to encourage highly skilled overseas workers to return to their home countries or relocate to other AMS.

Broaden the Scope of Digitalization in Mobile Financial Services

The shift towards electronic payments is evident across AMS, aiming to reduce reliance on physical cash and embrace the digital economy more extensively. Consequently, regulatory frameworks need restructuring to leverage the widespread use of smartphones in the region, fostering innovation in financial services and transactions. Three key regulatory aspects are essential for nurturing mobile financial services: firstly, implementing industry-friendly and pragmatic regulations to foster mobile financial services; secondly, enacting horizontal regulations encompassing robust network security, privacy, data protection, and electronic signatures across departments; and thirdly, harmonizing clear and concise

regulations for digital payments across ASEAN to facilitate cross-border trade and remittances.

Currently, several progressive countries are moving towards establishing and harnessing the advantages of digital banks. However, in many ASEAN nations, the focus remains on a bank-led approach as opposed to an operator-led model. Policymakers should permit the establishment of digital-only banks and work towards expanding existing mobile payment systems while retaining traditional banks and encouraging diverse banking operating models. This approach will contribute to enhancing financial inclusion across the region. ASEAN countries could look to China as a model, where rapid adoption of banking technology and the popularity of mobile banking are evident. In China, mobile phones are ubiquitous, facilitating cashless payments through various advanced methods such as facial recognition or fingerprint scanning. Conversely, in Europe, there's a significant surge in financial technology (Fintech) growth, notably with the emergence of digital-only banks, attributed partly to relaxed regulations in this sector.

Promote Entrepreneurship and Strengthening Trust and Security

To invigorate the digital economy, policymakers in the region should encourage innovative investment in emerging Internet companies that offer tailored solutions and unique value propositions to consumers. These startups should have the flexibility to innovate, while also adhering to stringent corporate governance standards as they grow, including compliance with regulations similar to those governing traditional telecom operators in areas such as interoperability and emergency services. National regulatory bodies and relevant ministries must collaborate closely to facilitate this process.

As ASEAN progresses towards becoming a seamless digital community with a growing reliance on online services, the associated risks of security breaches and data privacy violations are also on the rise. Businesses encounter significant hurdles in navigating data privacy regulations and ensuring compliance. Therefore, it is crucial to establish a robust and comprehensive cybersecurity framework that operates at both local and regional levels to effectively address cross-border incidents. This coordinated approach will bolster public trust in e-commerce and facilitate the smooth flow of cross-border data. ASEAN leaders should explore the establishment of an international agency dedicated to combating cybercrime. However, it is essential to maintain a balanced regulatory environment to support the growth of e-commerce and mobile commerce platforms without unduly inhibiting innovation.

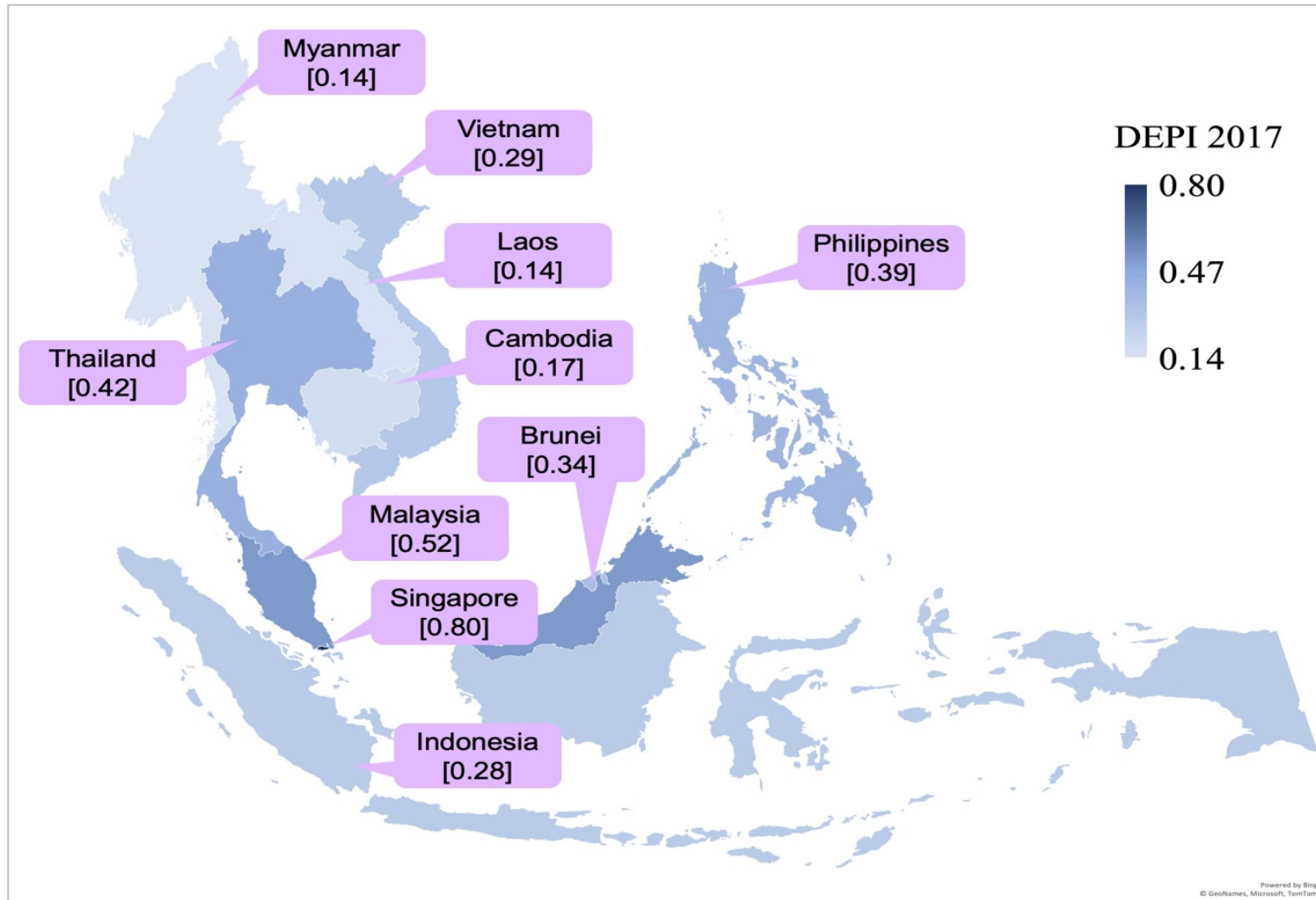


Figure 4.6: Visualisation of AMS DEPI 2017 in Heat Map

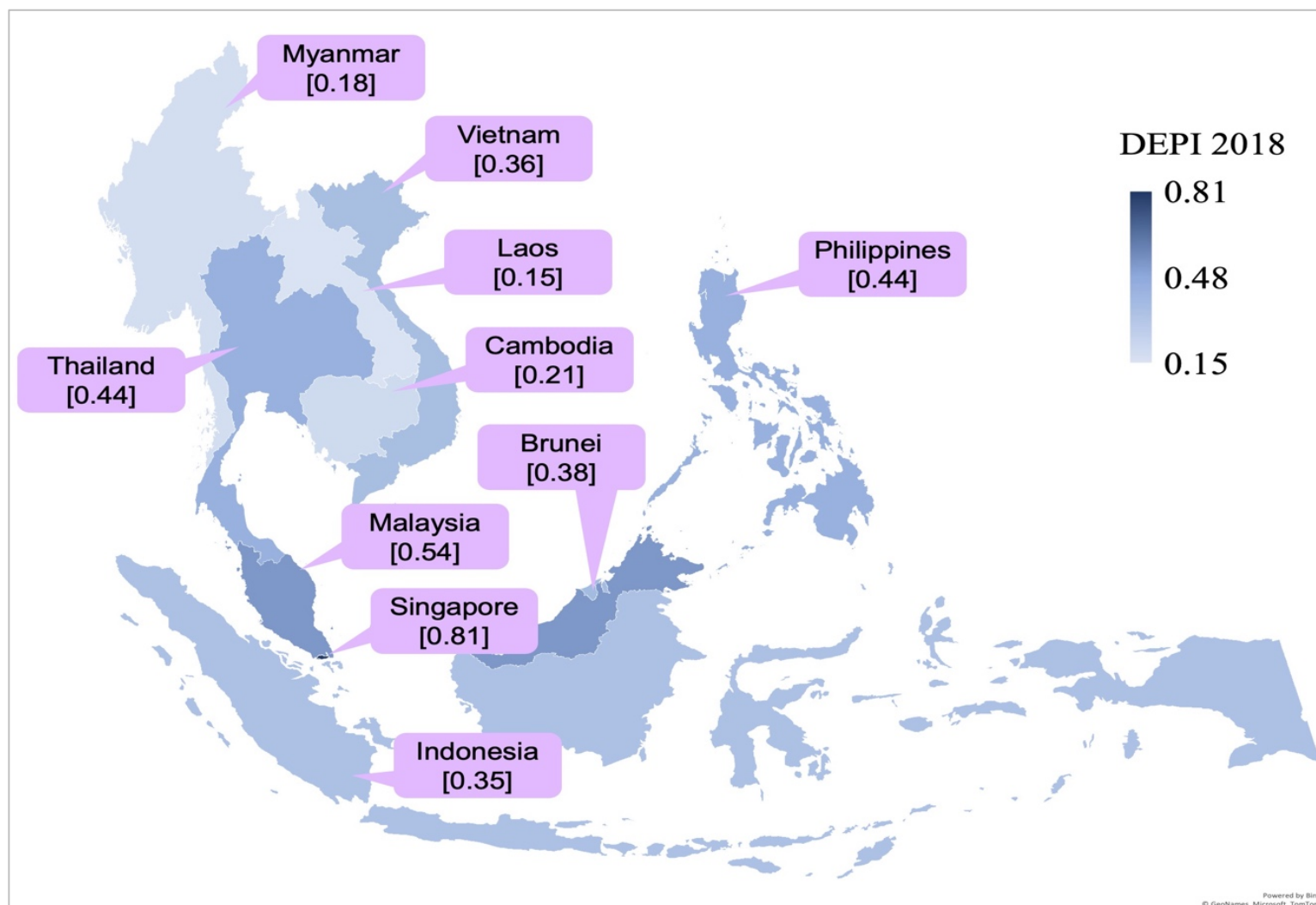


Figure 4.7: Visualisation of AMS DEPI 2018 in Heat Map

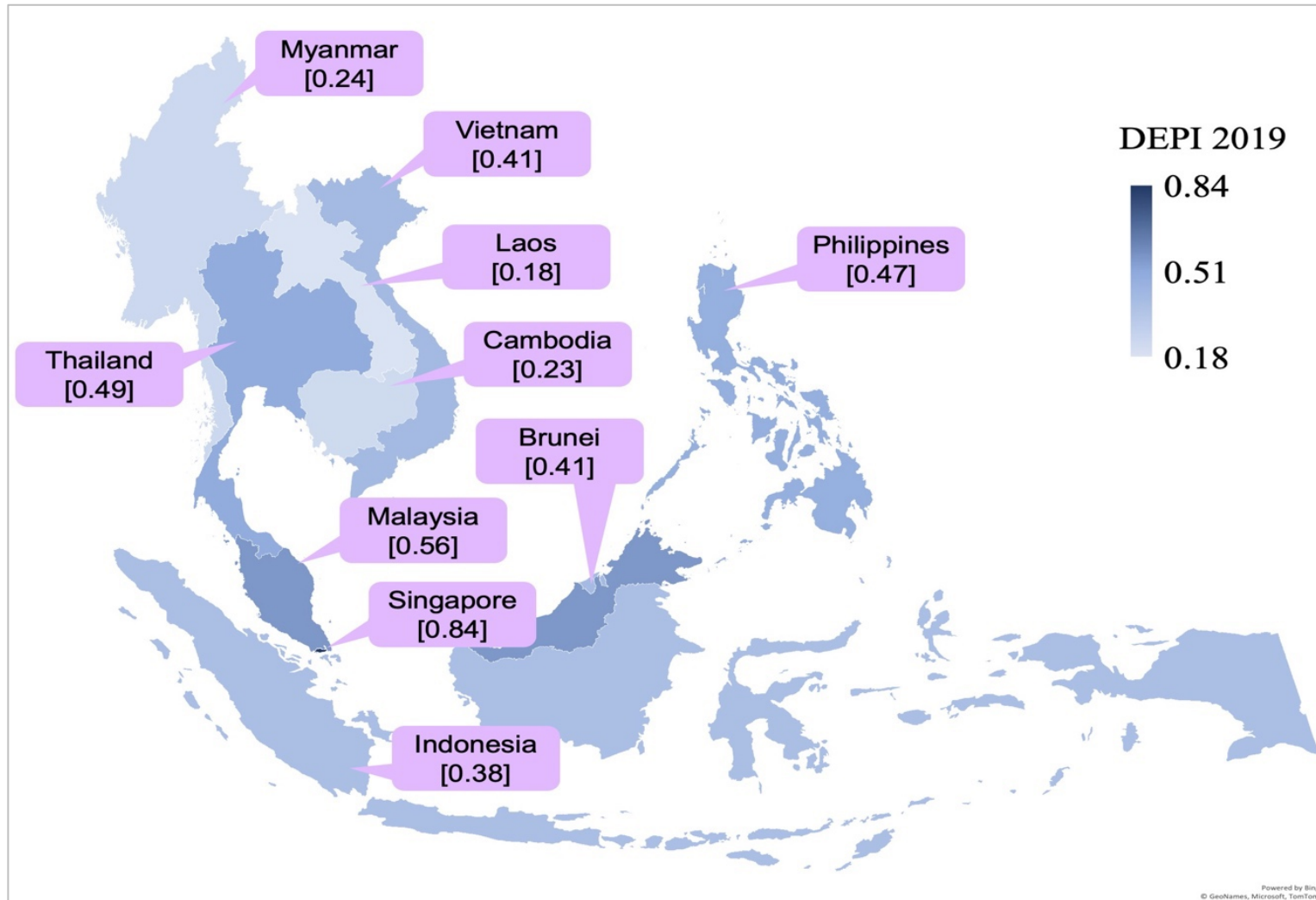


Figure 4.8: Visualisation of AMS DEPI 2019 in Heat Map

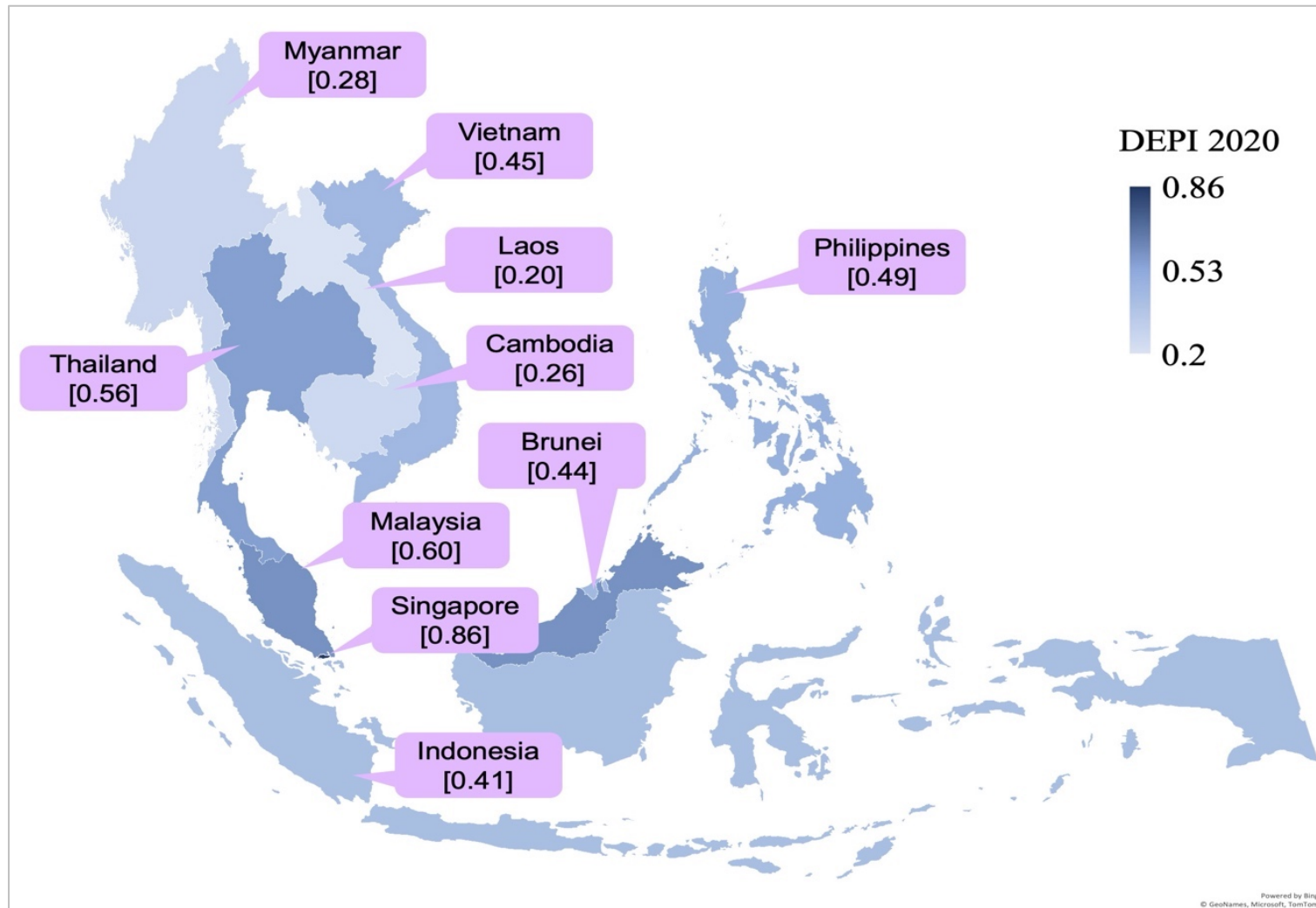


Figure 4.9: Visualisation of AMS DEPI 2020 in Heat Map

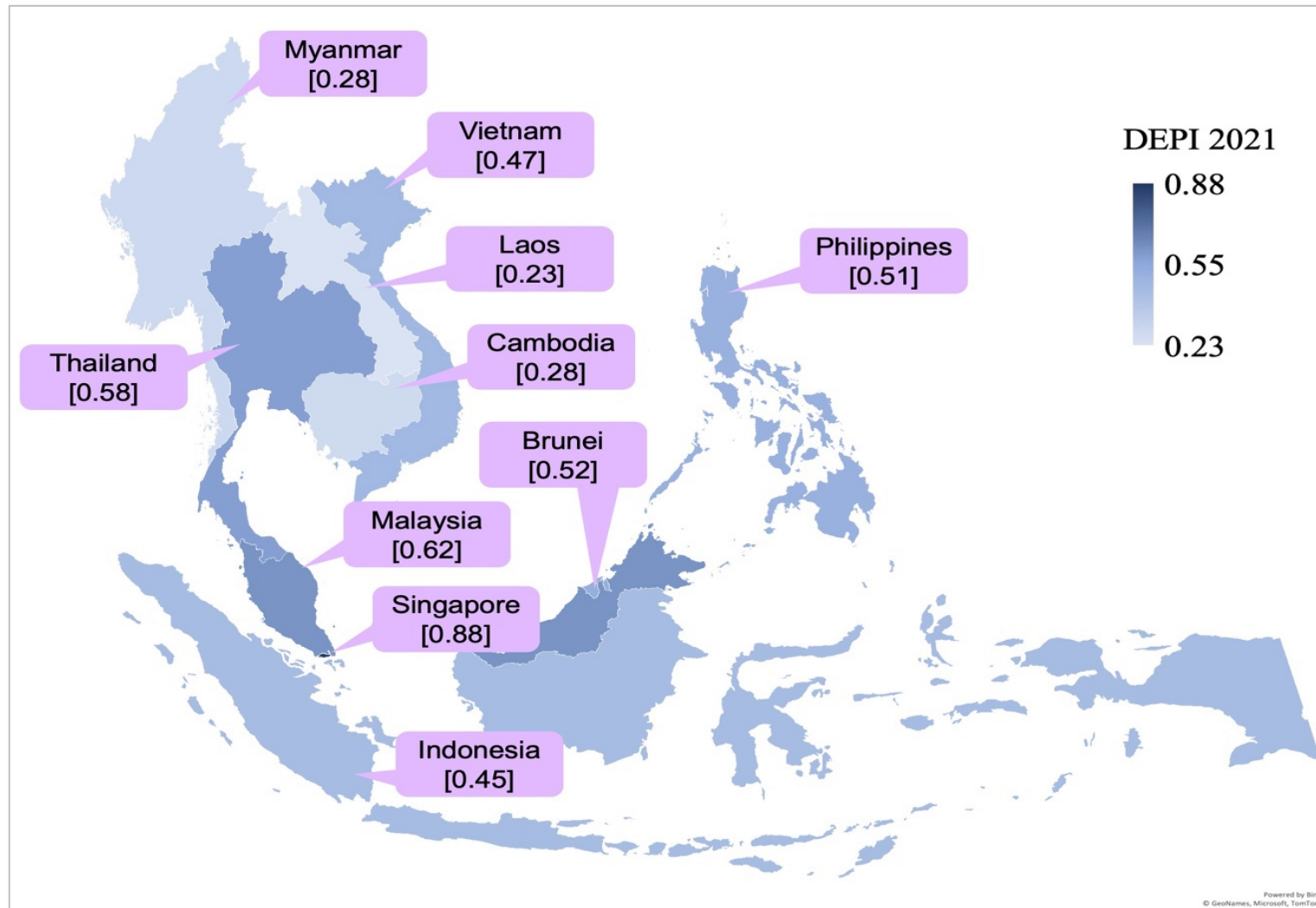


Figure 4.10: Visualisation of AMS DEPI 2021 in Heat Map

Table 4.4: Summary Changes of AMS Performance from 2017 to 2021

Country	DEPI 2017	DEPI 2018	DEPI 2019	DEPI 2020	DEPI 2021
Brunei	0.34	0.38	0.41	0.44	0.52
Indonesia	0.28	0.35	0.38	0.41	0.45
Cambodia	0.17	0.21	0.23	0.26	0.28
Lao	0.14	0.15	0.18	0.20	0.23
Myanmar	0.14	0.18	0.24	0.28	0.28
Malaysia	0.52	0.54	0.56	0.60	0.62
Philippines	0.39	0.44	0.47	0.49	0.51
Singapore	0.80	0.81	0.84	0.86	0.88
Thailand	0.42	0.44	0.49	0.56	0.58
Vietnam	0.29	0.36	0.41	0.45	0.47

For intra-country perspective, each country's DEPI score has shown a general upward trend from 2017 to 2021, indicating improvements in digital economic performance. Previous literature suggests that the ASEAN region exhibits varying levels of digital development due to policy differences, infrastructure gaps, and investment disparities (Shen et al., 2015). The trends in Table 4.4 indicate progressive digital growth, particularly in Singapore and Malaysia, which aligns with studies by Li et al. (2012) that highlight policy-driven digital acceleration. In contrast, nations such as Myanmar and Cambodia, with lower DEPI scores, mirror the findings of Vu (2019), who discusses challenges in emerging economies' digital integration. Countries like Singapore and Malaysia maintain a strong lead, while Myanmar, Lao, and Cambodia have relatively lower DEPI scores. Some countries experienced significant growth over the years, e.g., Indonesia (0.28 to 0.45, increase of 0.17) and Vietnam (0.29 to 0.47, increase of 0.18), showing rapid digital economic advancements. Singapore had only a slight increase (0.80 to 0.88), which suggests that it was already at a high level of digital development with limited room for drastic improvement. The digital

gap between leading (Singapore) and lagging countries (Myanmar, Lao, Cambodia) remains significant. Countries such as Brunei, Thailand, and the Philippines show steady improvements, suggesting a closing gap between mid-tier and high-tier digital economies.

In terms of between intercountry perspective, there is a clear divide between high-performing economies (Singapore, Malaysia) and developing economies (Myanmar, Lao, Cambodia). This may be due to differences in technological infrastructure, policy support, and economic capacity. Indonesia and Vietnam are emerging digital players, rapidly improving their DEPI scores and closing the gap with Malaysia and Thailand. Brunei's growth from 0.34 to 0.51 suggests strong digital transformation efforts, possibly due to policy initiatives. Singapore and Malaysia exhibit stable and predictable digital growth. Myanmar and Lao show fluctuations, possibly due to political, economic, or technological challenges affecting digital adoption. Southeast Asia is undergoing digital transformation, but progress is uneven across countries. Countries with strong governmental support, infrastructure, and investment (e.g., Singapore, Malaysia, Thailand) maintain leadership positions. Emerging economies (e.g., Indonesia, Vietnam) are showing the most rapid digital growth, highlighting their potential as future regional leaders. Less-developed economies (e.g., Myanmar, Lao, Cambodia) need more focused efforts on digital infrastructure and policies to catch up. Figure 4.11 shows the ranking comparison of AMS in terms of their DEPI across from 2017 to 2021.

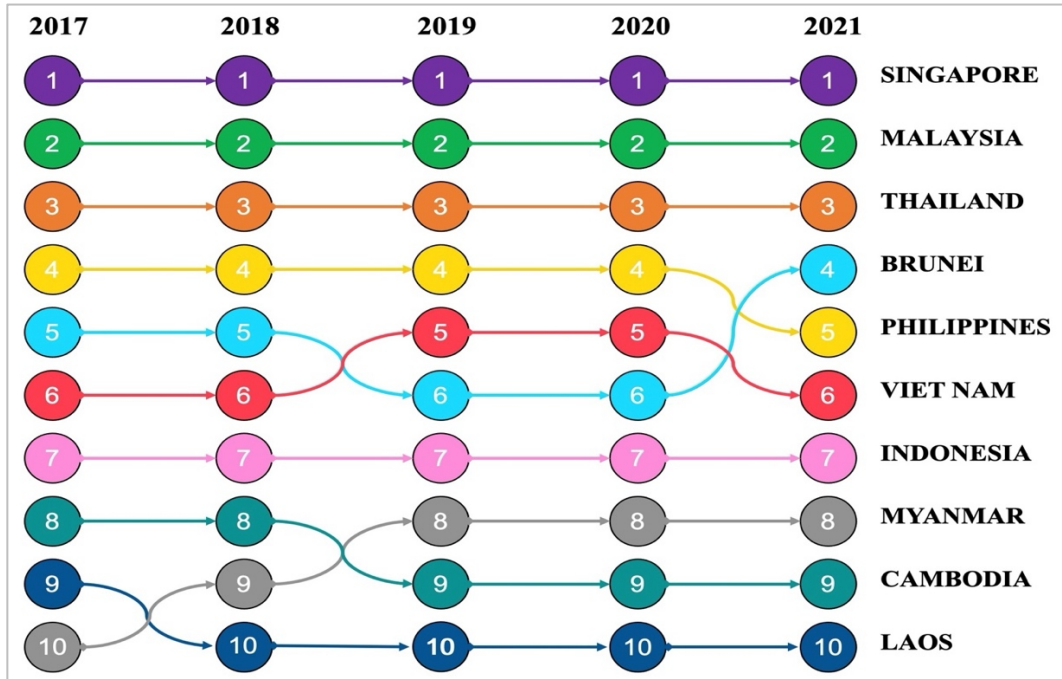


Figure 4.11: Ranking Comparison of AMS in terms of DEPI across Years

4.5 Sensitivity Analysis

The sensitivity analysis conducted on the Digital Economy Performance Index (DEPI) scores from 2017 to 2021 provides valuable insights into the robustness and reliability of the results. Sensitivity analysis is a critical tool for assessing how changes in weighting methods (in this case, entropy weighting vs. equal weighting) affect the rankings and scores of countries. By comparing the DEPI scores and rankings under both weighting schemes, we can evaluate the stability and consistency of the results, which is essential for ensuring the reliability of the index.

Key observations from the sensitivity analysis as depicted in Table 4.5:

i. Consistency in Rankings:

Over the five-year period, the rankings of countries under both entropy and equal weighting methods show a high degree of consistency. For example, Singapore consistently ranks 1st in both weighting schemes across all years, indicating that its position as the top

performer in the digital economy is robust and not sensitive to the choice of weighting method.

Similarly, Malaysia and Thailand maintain relatively stable rankings, typically occupying the 2nd and 3rd positions, respectively. This consistency suggests that these countries' digital economy performances are reliably captured by the DEPI, regardless of the weighting approach.

ii. Moderate Sensitivity in Middle-Ranked Countries:

Countries in the middle of the rankings, such as Vietnam, Philippines, and Brunei, exhibit some sensitivity to the weighting method. For instance, in 2021, Vietnam ranks 6th under entropy weighting but 5th under equal weighting. Similarly, the Philippines ranks 5th under entropy weighting but 7th under equal weighting in the same year.

This moderate sensitivity is expected, as middle-ranked countries often have more closely clustered scores, making their rankings more susceptible to changes in weighting methods. However, the overall stability of their positions (within 1-2 ranks) suggests that the DEPI results are still reasonably robust for these countries.

iii. Low Sensitivity in Lower-Ranked Countries:

Lower-ranked countries such as Cambodia, Lao, and Myanmar show minimal sensitivity to the weighting method. Their rankings remain relatively unchanged across both weighting schemes, indicating that their digital economy performances are consistently captured by the DEPI.

For example, Lao consistently ranks 10th across all years under both weighting methods, reflecting its persistent challenges in digital economy development.

iv. Gradual Improvement Over Time:

The sensitivity analysis also highlights the gradual improvement in DEPI scores for most countries over the five-year period. For instance, Brunei's DEPI score increased from 0.34 in 2017 to 0.52 in 2021 under entropy weighting, reflecting steady progress in its digital economy. This trend is consistent across both weighting methods, further supporting the reliability of the results.

Table 4.5: Comparison of Results between Entropy and Equal Weight

	2017			
Country	DEPI Score (Entropy)	DEPI Score (Equal Weight)	Rank (Entropy)	Rank (Equal Weight)
Brunei	0.34	0.43	5	5
Cambodia	0.17	0.30	8	8
Indonesia	0.28	0.40	7	7
Lao	0.14	0.23	10	10
Malaysia	0.52	0.55	2	2
Myanmar	0.14	0.27	10	9
Philippines	0.39	0.45	4	4
Singapore	0.8	0.75	1	1
Thailand	0.42	0.46	3	3
Vietnam	0.29	0.43	6	5
	2018			
Country	DEPI Score (Entropy)	DEPI Score (Equal Weight)	Rank (Entropy)	Rank (Equal Weight)
Brunei	0.38	0.42	5	7
Indonesia	0.35	0.46	7	6
Cambodia	0.21	0.34	8	8
Lao	0.15	0.24	10	10
Myanmar	0.18	0.31	9	9
Malaysia	0.54	0.58	2	2
Philippines	0.44	0.50	3	3
Singapore	0.81	0.73	1	1
Thailand	0.44	0.49	3	4
Vietnam	0.36	0.49	6	4

Table 4.5 continued

	2019			
Country	DEPI Score (Entropy)	DEPI Score (Equal Weight)	Rank (Entropy)	Rank (Equal Weight)
Brunei	0.41	0.45	5	7
Indonesia	0.38	0.48	7	6
Cambodia	0.23	0.36	9	9
Lao	0.18	0.27	10	10
Myanmar	0.24	0.38	8	8
Malaysia	0.56	0.60	2	2
Philippines	0.47	0.52	4	4
Singapore	0.84	0.77	1	1
Thailand	0.49	0.53	3	3
Vietnam	0.41	0.51	5	5
	2020			
Country	DEPI Score (Entropy)	DEPI Score (Equal Weight)	Rank (Entropy)	Rank (Equal Weight)
Brunei	0.44	0.48	6	7
Indonesia	0.41	0.51	7	6
Cambodia	0.26	0.38	9	9
Lao	0.2	0.30	10	10
Myanmar	0.28	0.42	8	8
Malaysia	0.6	0.63	2	2
Philippines	0.49	0.52	5	5
Singapore	0.86	0.76	1	1
Thailand	0.56	0.60	3	3
Vietnam	0.45	0.55	4	4
	2021			
Country	DEPI Score (Entropy)	DEPI Score (Equal Weight)	Rank (Entropy)	Rank (Equal Weight)
Brunei	0.52	0.58	4	4
Indonesia	0.45	0.54	7	6
Cambodia	0.28	0.40	8	9
Lao	0.23	0.33	10	10
Myanmar	0.28	0.41	8	8
Malaysia	0.62	0.64	2	2
Philippines	0.51	0.53	5	7
Singapore	0.88	0.82	1	1
Thailand	0.58	0.62	3	3
Vietnam	0.47	0.56	6	5

The sensitivity analysis demonstrates that the DEPI results are robust and reliable for several reasons:

i. High Consistency in Rankings:

The consistent rankings of top and bottom-performing countries across both weighting methods indicate that the DEPI is capturing meaningful differences in digital economy performance. This consistency is a strong indicator of the index's robustness (Saltelli et al., 2008).

ii. Moderate Sensitivity in Middle Rankings:

While middle-ranked countries show some sensitivity to weighting methods, the changes in their rankings are minor and do not significantly alter the overall interpretation of the results. This level of sensitivity is typical in composite indices and does not undermine the reliability of the DEPI (OECD, 2008).

iii. Gradual and Consistent Improvement:

The steady improvement in DEPI scores over time, observed across both weighting methods, suggests that the index is effectively tracking progress in digital economy development. This consistency over time further validates the reliability of the DEPI.

iv. Alignment with Theoretical Expectations:

The results align with theoretical expectations, where more developed economies (e.g., Singapore, Malaysia) consistently outperform less developed ones (e.g., Lao, Cambodia). This alignment reinforces the credibility of the DEPI as a measure of digital economy performance.

The sensitivity analysis confirms that the DEPI results are robust and reliable, with consistent rankings for top and bottom-performing countries and only minor variations for middle-ranked countries. The gradual improvement in scores over time further supports the

index's ability to track digital economy development accurately. These findings underscore the DEPI's utility as a tool for policymakers and researchers to assess and compare digital economy performance across ASEAN member states.

4.6 Country Findings

This section presents the individual findings of AMS, looking at their respective strengths and weaknesses based on DEPI scores, and identifying some of the outstanding initiatives they have implemented or are looking to implement that will facilitate their digital integration in various dimensions.

4.6.1 Brunei Darussalam

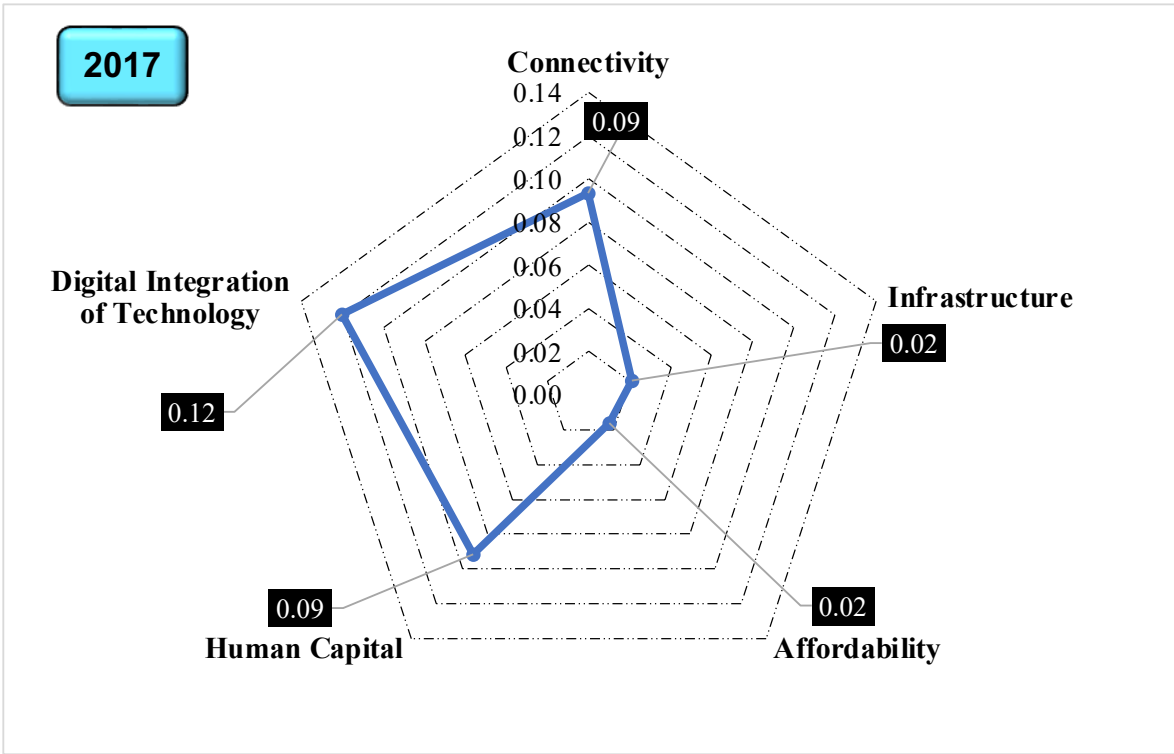
Brunei excels in human capital and digital technology integration among its dimensions. It introduced its inaugural Digital Economy Master Plan (DEMP) 2025 on June 4, 2020, aligning with national goals and aspirations outlined in Wawasan 2035. The DEMP 2025 prioritizes industry and government digitalization, fostering digital industries, and enhancing human talent development.

Additionally, Brunei established the Council for the Promotion of Technology and Scientific Research (CREATES) to support science, technology, and innovation activities, thereby advancing economic and social development in line with Wawasan 2035.

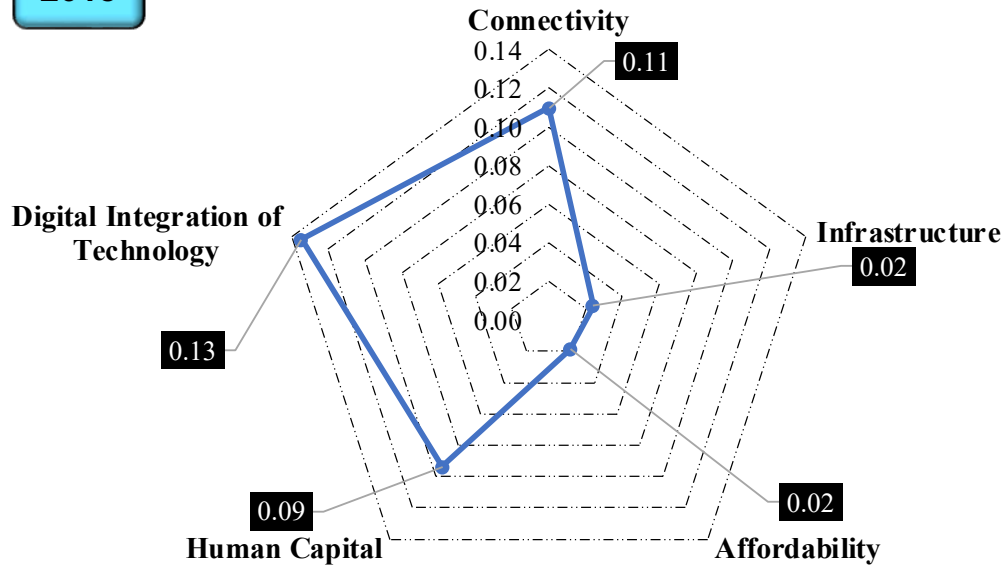
Despite being a developed nation where internet subscriptions are affordable for citizens, Brunei's affordability dimension scores moderately. Nevertheless, the 2018 E-Commerce Survey conducted by the Information and Communications Technology Industry (AITI) revealed high adoption rates of e-commerce and digital payments, with a majority of respondents utilizing credit or debit cards for online transactions, followed by online bank transfers and e-wallets.

Furthermore, Brunei Darussalam Central Bank (BDCB) introduced a digital payments roadmap spanning from 2019 to 2025, aiming to establish a National Payments Center. This initiative offers various digital payment options such as online and mobile banking, QR code mobile payments, and e-commerce, highlighting Brunei's dedication to fostering financial innovation and digital finance.

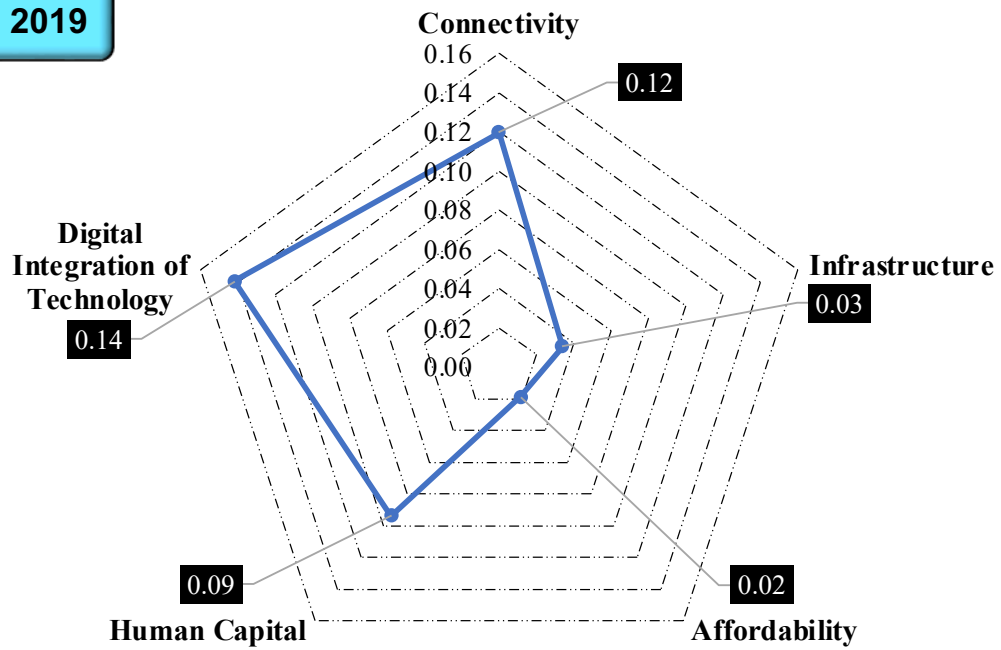
Recent studies have shown that Brunei's focus on digital payments aligns with global trends, where countries are increasingly adopting digital financial services to enhance economic resilience (Smith & Johnson, 2020). The establishment of the National Payments Center is a strategic move that could position Brunei as a regional leader in digital finance, similar to Singapore's success in this domain (Lee et al., 2019).



2018



2019



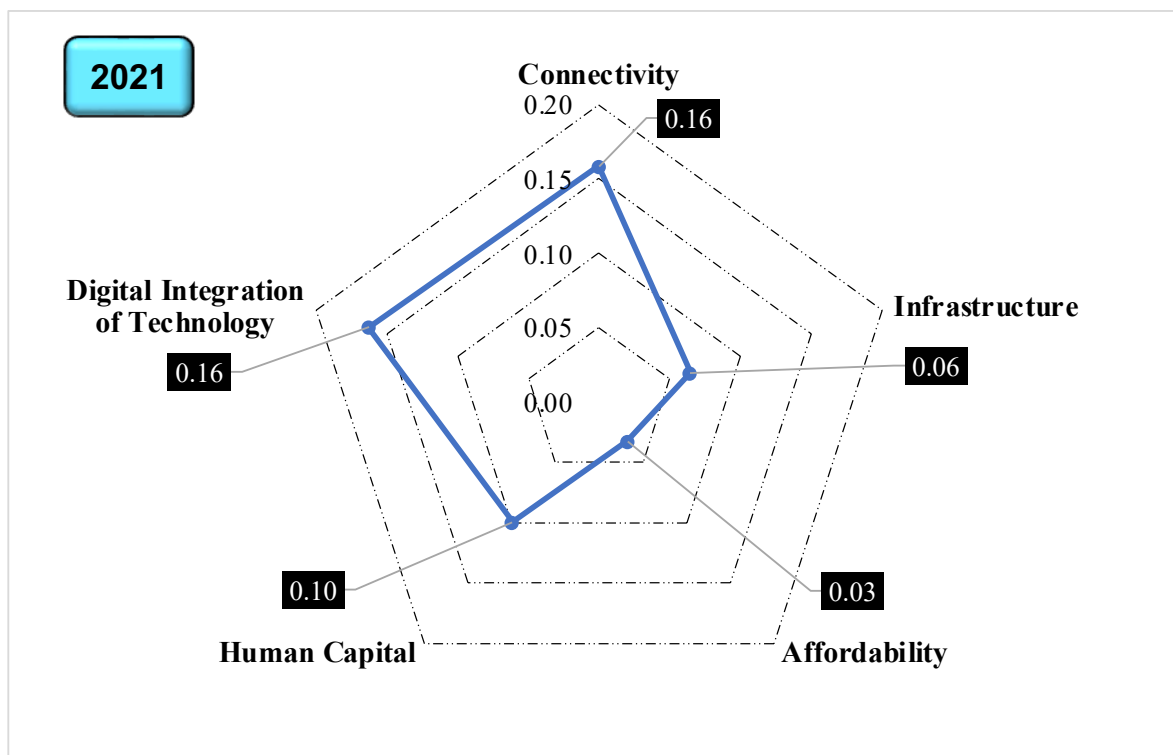
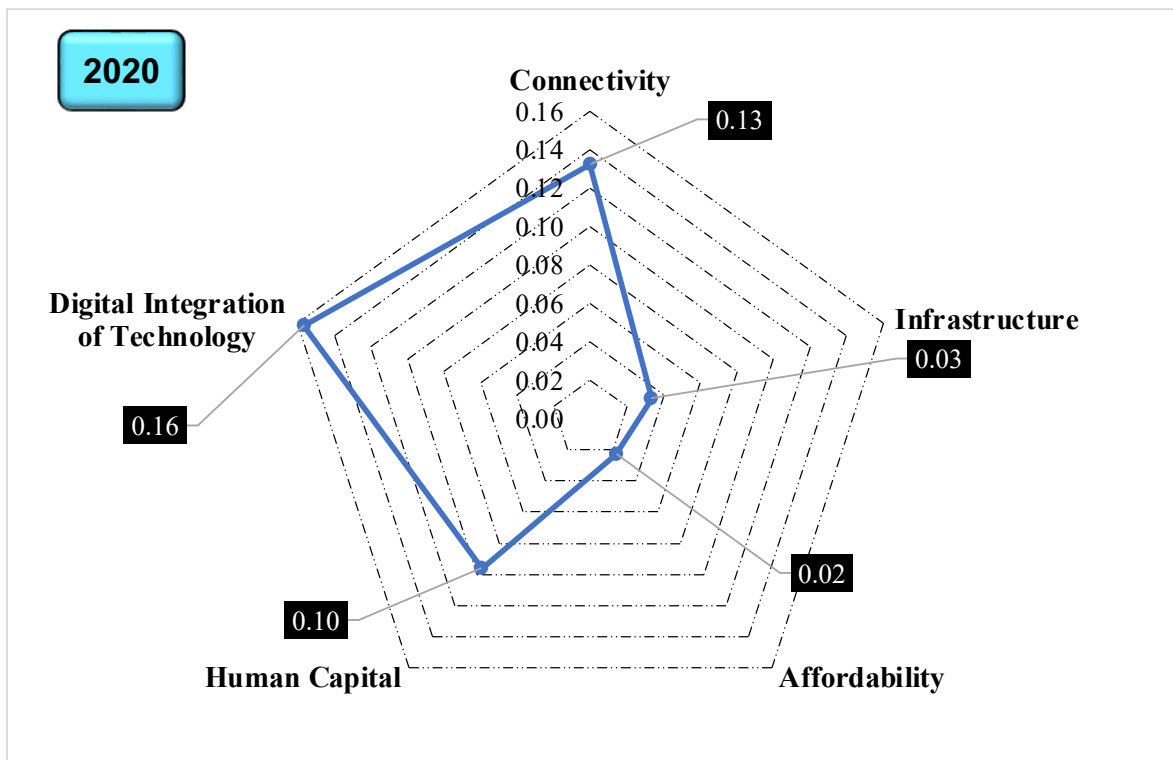


Figure 4.12: Dimensional Score of Brunei DEPI from 2017-2021

4.6.2 Cambodia

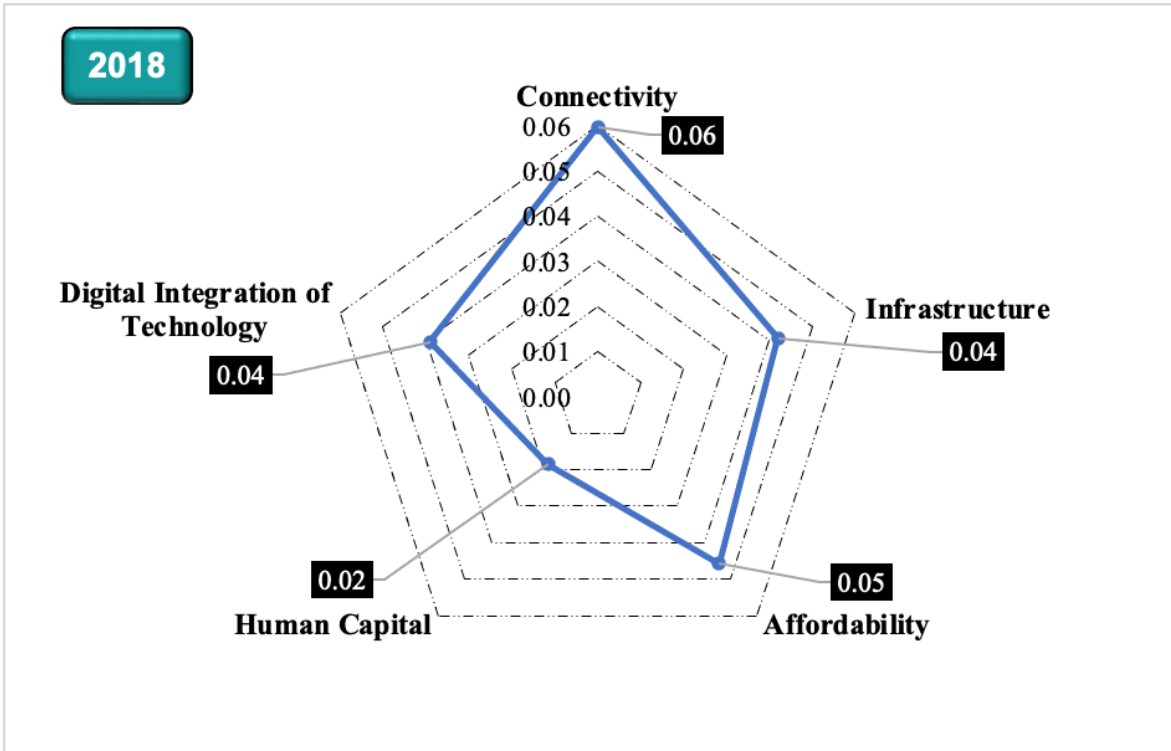
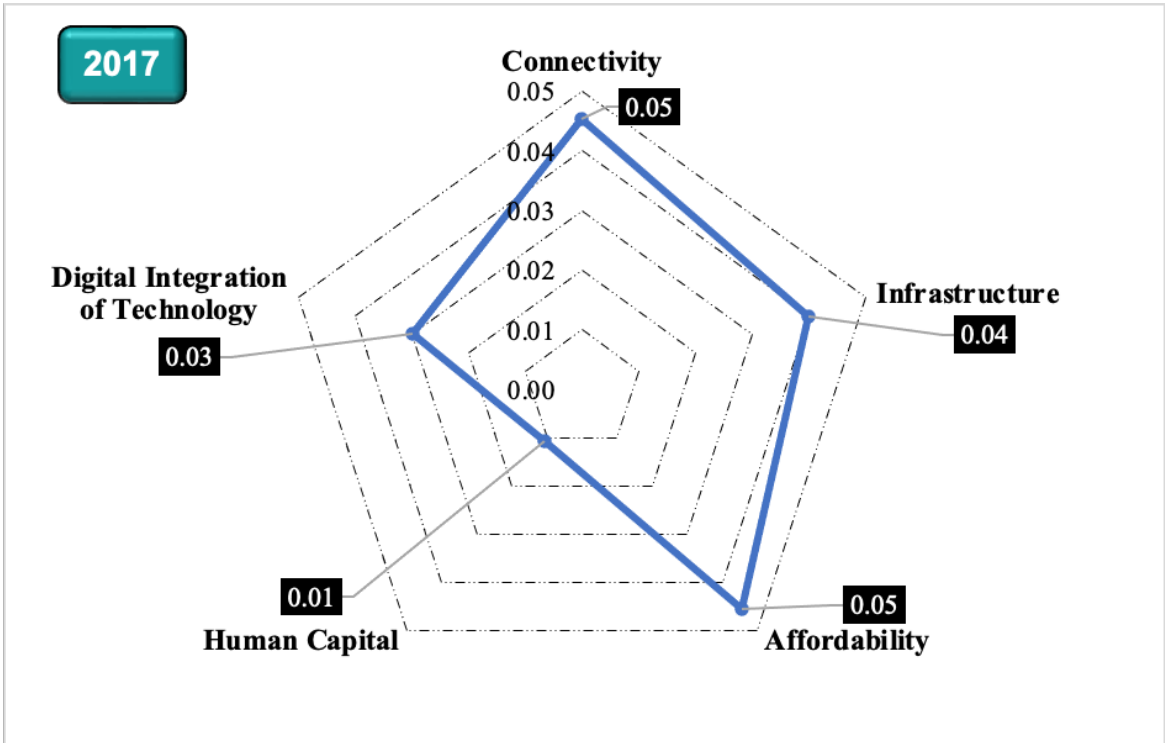
Cambodia has shown weak development in terms of human capital throughout the study period, indicating a need for improvement in personnel capabilities and digital literacy. To address this, the Cambodia Academy of Digital Technology (CADT) has been established under the Ministry of Posts and Telecommunications (MPTC) to offer formal training, research, and education on ICT. CADT also plays a key role in ICT research and development efforts in the country, fostering collaboration between the public and private sectors and supporting small and medium-sized enterprises.

In terms of digital technology integration, the Bakong Project, a blockchain-based peer-to-peer payments and remittance platform initiated by the National Bank of Cambodia, is expected to enhance the adoption of digital financial services. With support for instant mobile payments, QR code usage, and digital wallets, over 20 financial institutions have already partnered to participate in the system, with more expected to join in the future. Further progress is anticipated in the coming years.

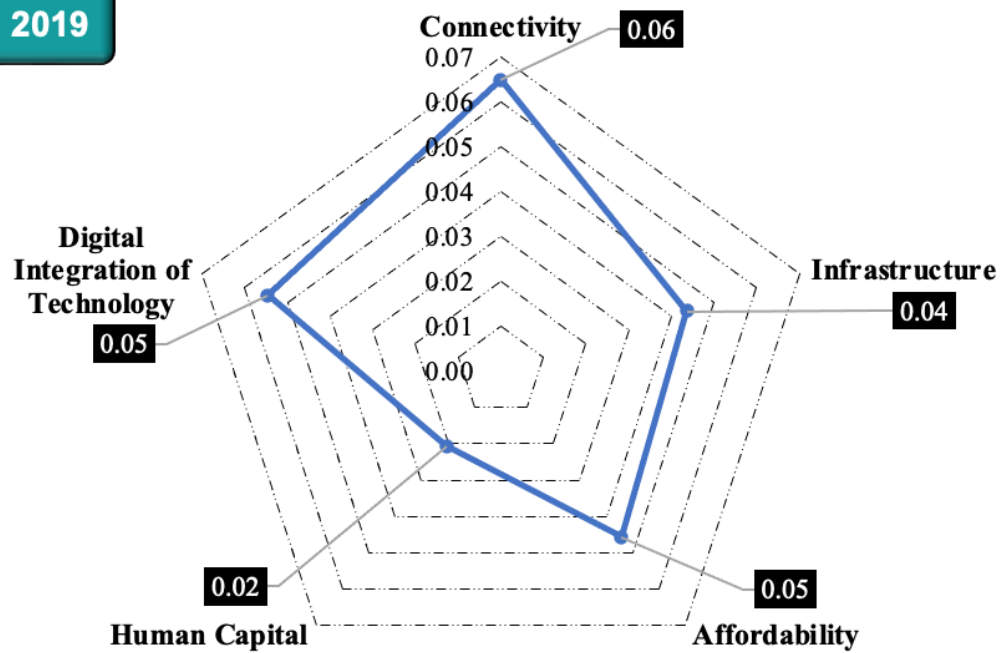
There is significant potential for improvement in Cambodia's Digital Economy Performance Index (DEPI) to catch up with regional trends. This entails promoting and expanding digital infrastructure throughout the country, along with government-led initiatives to encourage the availability and utilization of online services. Notably, the establishment of a single portal, in collaboration with six ministries and state agencies, aims to streamline services such as e-commerce registration, thereby reducing processing times. This initiative reflects positive momentum, and the government intends to further integrate additional departments into the system.

The Bakong Project is a significant step towards financial inclusion in Cambodia, as blockchain technology has been shown to reduce transaction costs and increase transparency

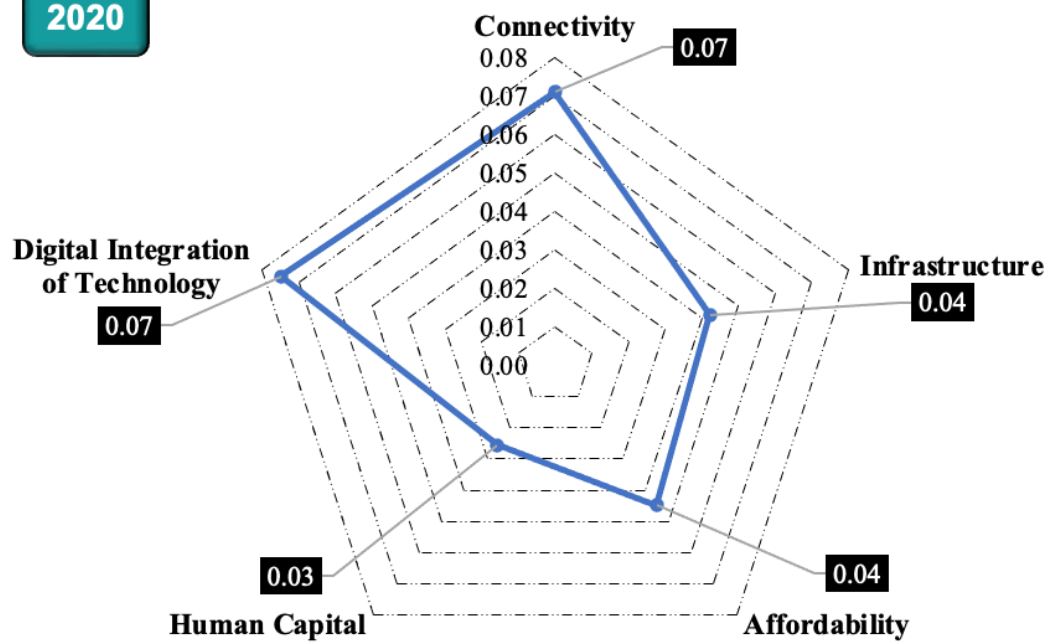
in financial systems (Nakamoto, 2008). However, challenges remain in scaling such initiatives, particularly in rural areas where digital literacy is low (World Bank, 2021).



2019



2020



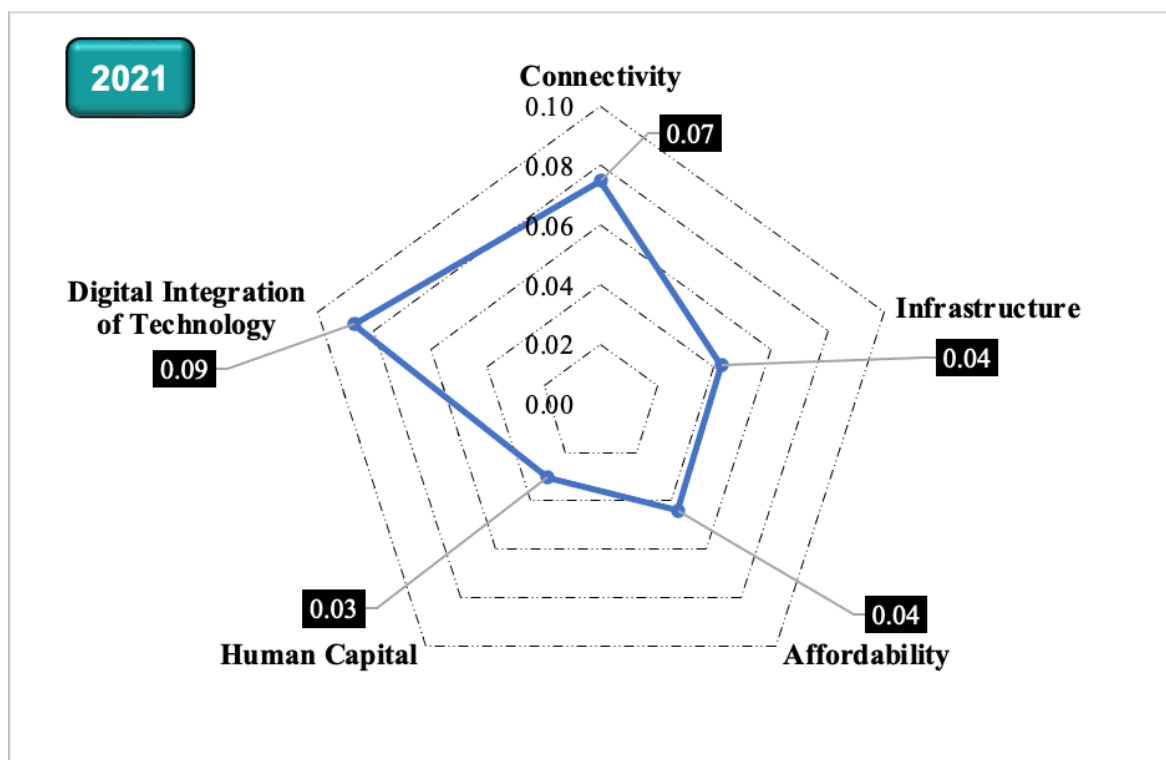


Figure 4.13: Dimensional Score of Cambodia DEPI from 2017-2021

4.6.3 Indonesia

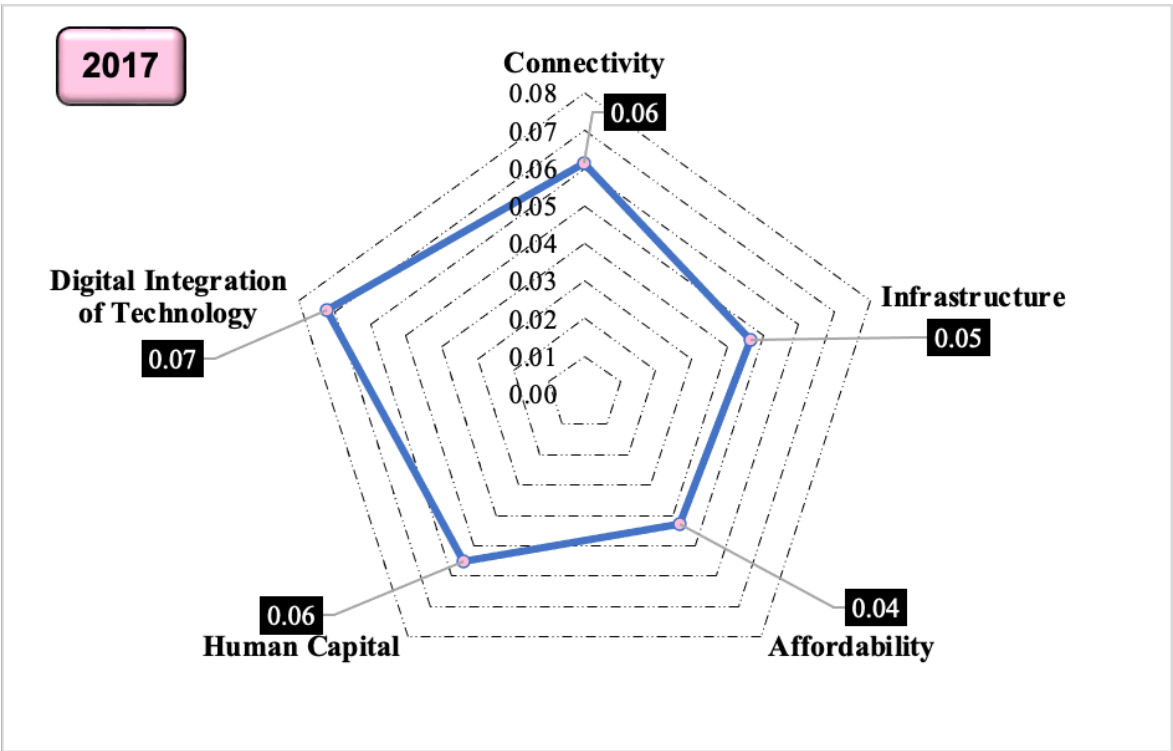
Indonesia has demonstrated commendable performance in the Digital Economy Performance Index (DEPI), with several dimension scores closely aligned with regional benchmarks. Despite facing challenges related to the digital divide, the outcomes of government efforts to enhance digital literacy and capabilities will require time to materialize.

To bridge the digital talent gap, the Indonesian government has implemented various measures to facilitate the transition of existing workers into technology-driven roles and equip future workers with skills relevant to an increasingly automated workplace. For instance, the Ministry of Communications and Informatics organizes the annual Digital Talent Scholarship and collaborates with online marketplaces like Bukalapak, Tokopedia,

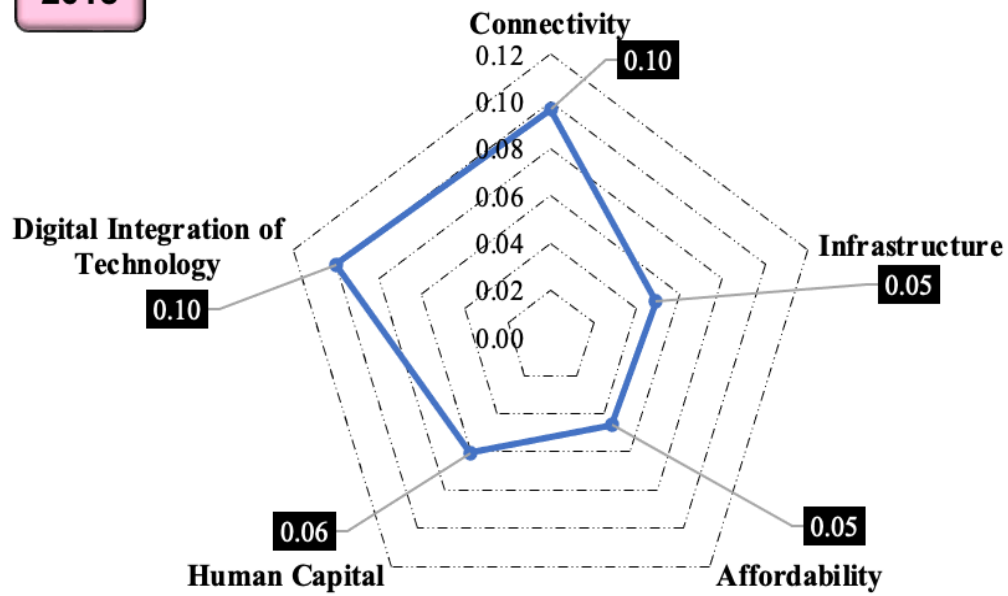
Shopee, and OLX to conduct training workshops for SMEs, enabling them to enhance their digital skills, conduct online sales, and utilize digital payments.

Additionally, the Ministry of Education is exploring the utilization of Massive Open Online Courses (MOOCs) to enhance the delivery of educational programs. Launched in 2019, the Kamp Kreatif SMK Indonesia (KKSI) initiative aims to leverage the latest technologies to enhance learning quality and innovation in vocational high schools, incorporating online videos and providing access to experts in various fields.

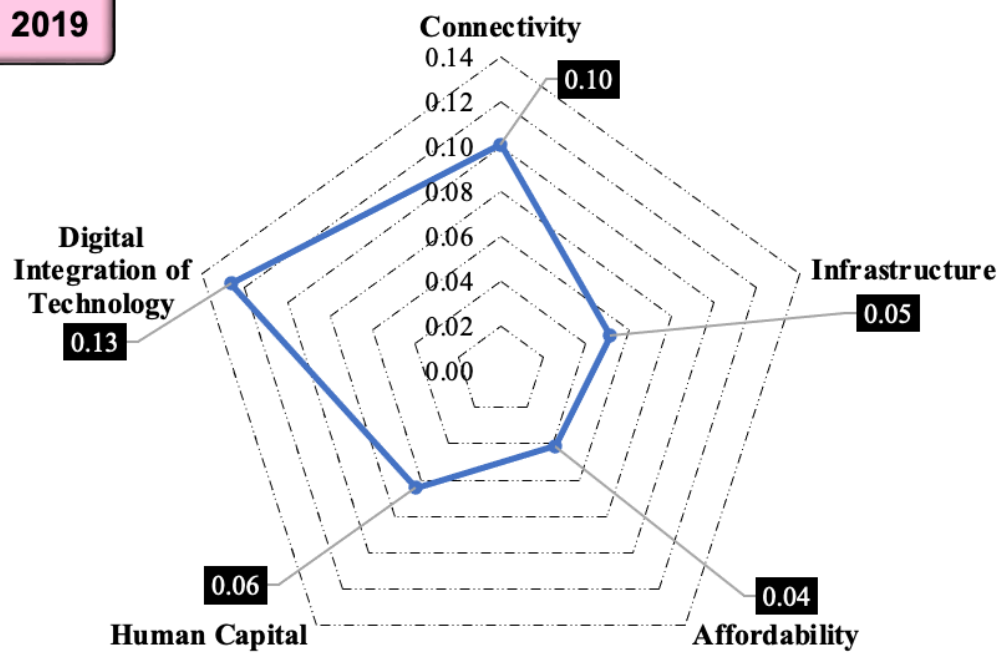
The use of MOOCs in Indonesia is part of a broader trend in Southeast Asia, where online education is seen as a key driver of digital literacy (UNESCO, 2020). However, the effectiveness of these programs depends on the availability of reliable internet access, which remains a challenge in rural areas (World Bank, 2021).



2018



2019



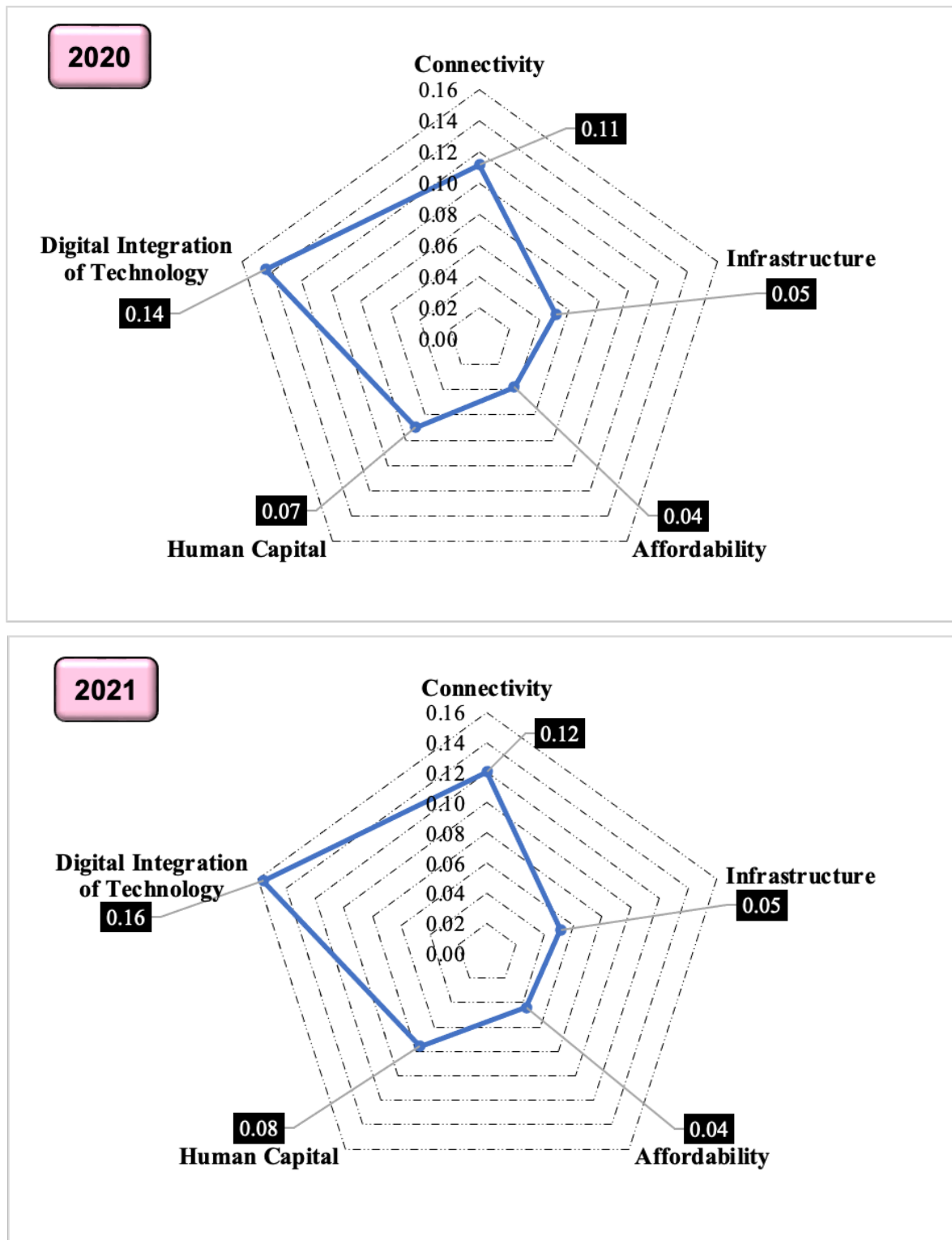


Figure 4.14: Dimensional Score of Indonesia DEPI from 2017-2021

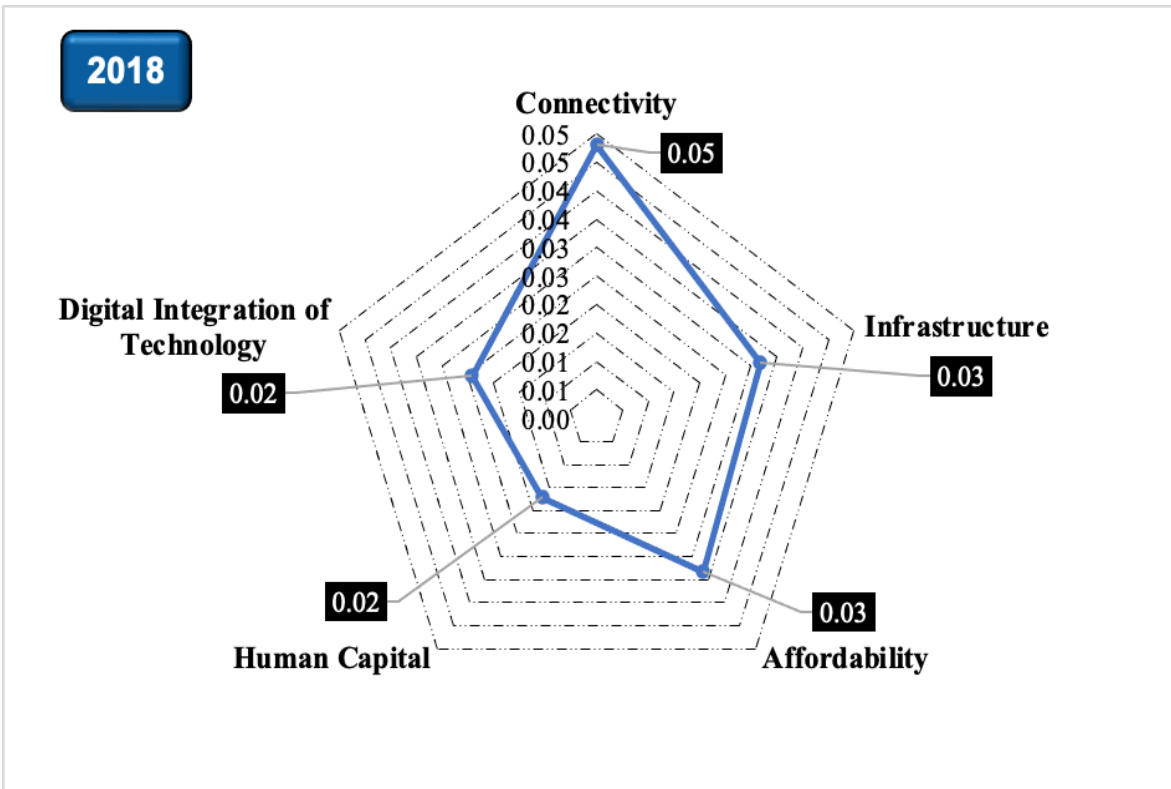
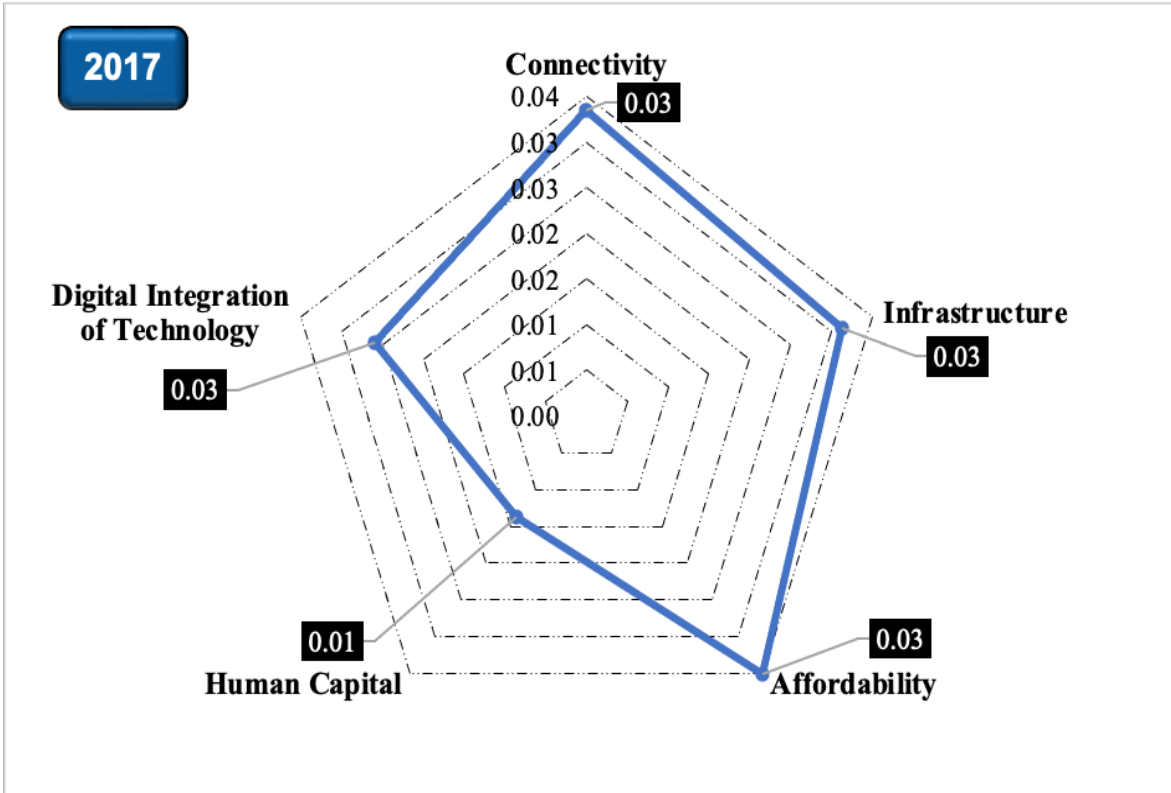
4.6.4 Lao

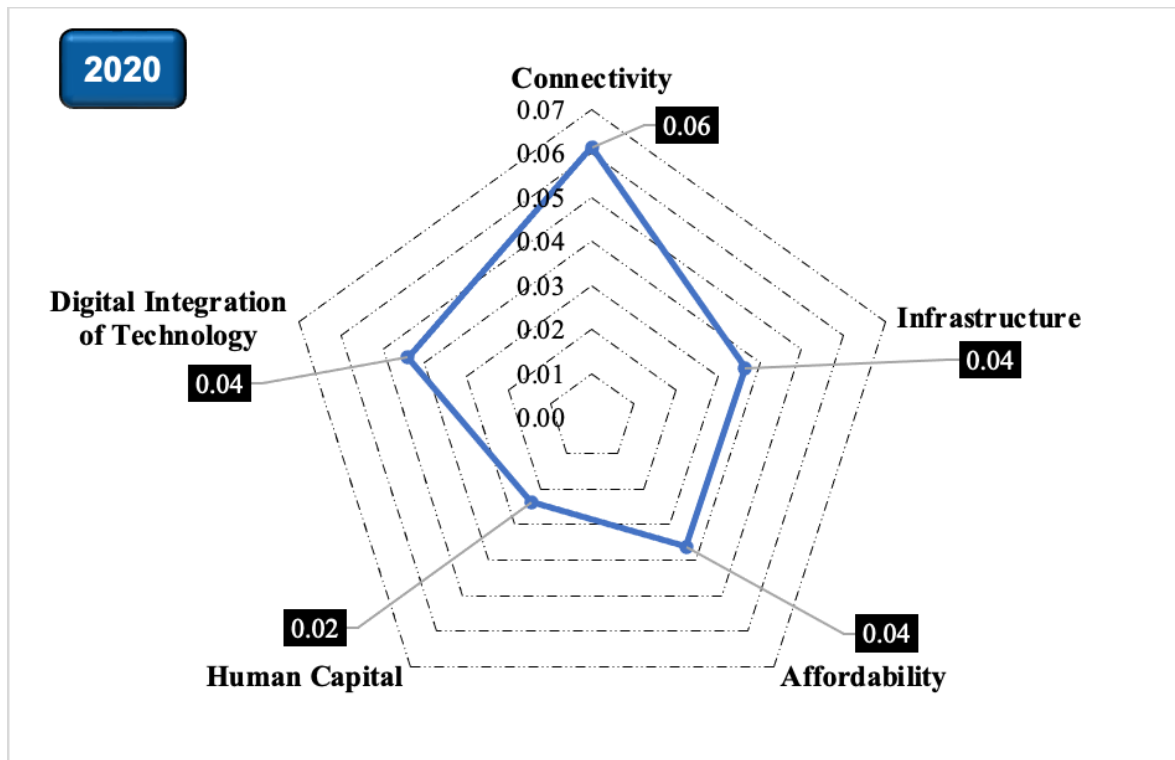
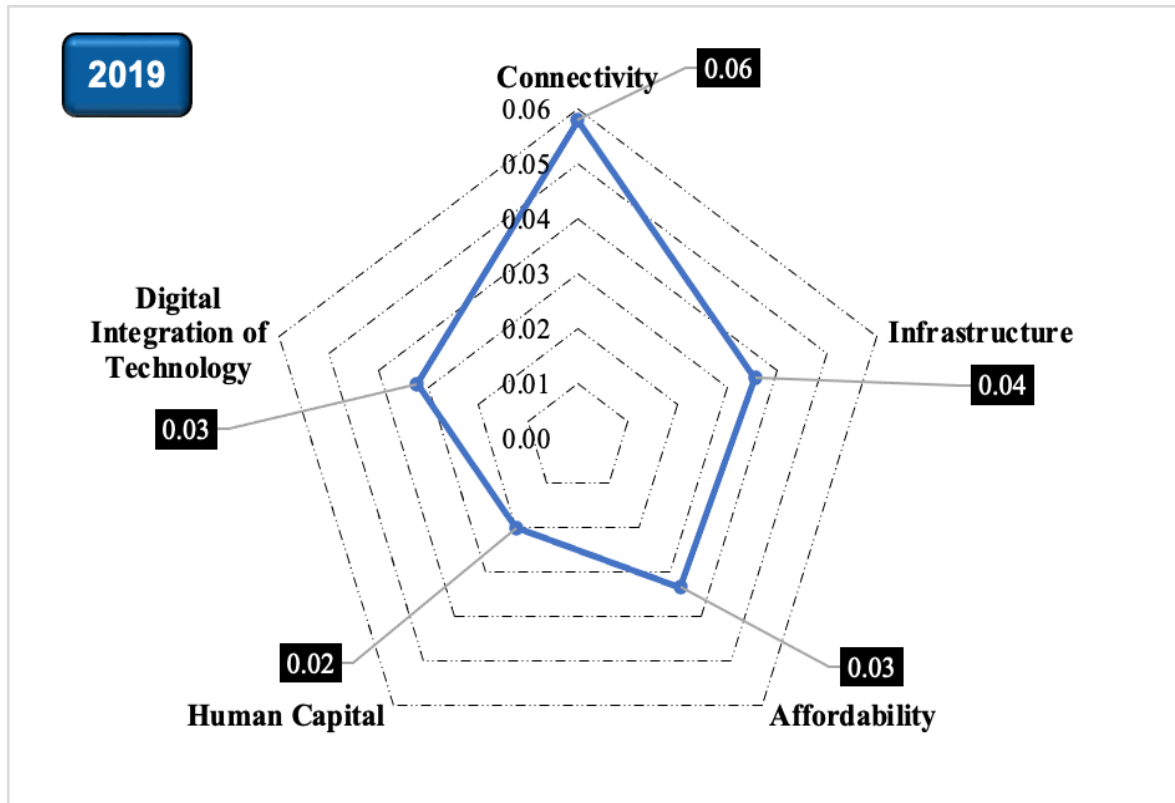
Lao's individual scores in the Digital Economy Performance Index (DEPI) continue to lag behind those of other ASEAN Member States (AMS), indicating room for improvement across all dimensions. Notably, advancements are anticipated in digital payments as identity and payment systems are further developed. To enhance citizens' access to public services, Lao has initiated trials for a digital basic identification system.

Lao must intensify its efforts in developing digital skills and talent to keep pace with the rapid digitalization occurring in the region. Organizations like Aide et Action have been active since 2018 in integrating digital technologies into schools to educate students on device and software usage. However, there remains a need for additional support, particularly in rural and remote schools lacking such resources.

Furthermore, to bolster e-government connectivity and infrastructure construction, the Lao Ministry of Science and Technology has engaged Unitel as a consultant to spearhead e-government and smart projects as part of the national digital transformation strategy. Additionally, collaboration with telecommunications providers is essential to expand internet coverage and adoption of internet services across Lao.

The challenges faced by Lao in digital transformation are similar to those in other developing countries, where infrastructure and digital literacy are major barriers (UNDP, 2020). The involvement of private sector players like Unitel is crucial, as public-private partnerships have been shown to accelerate digital transformation in other ASEAN countries (ASEAN Secretariat, 2019).





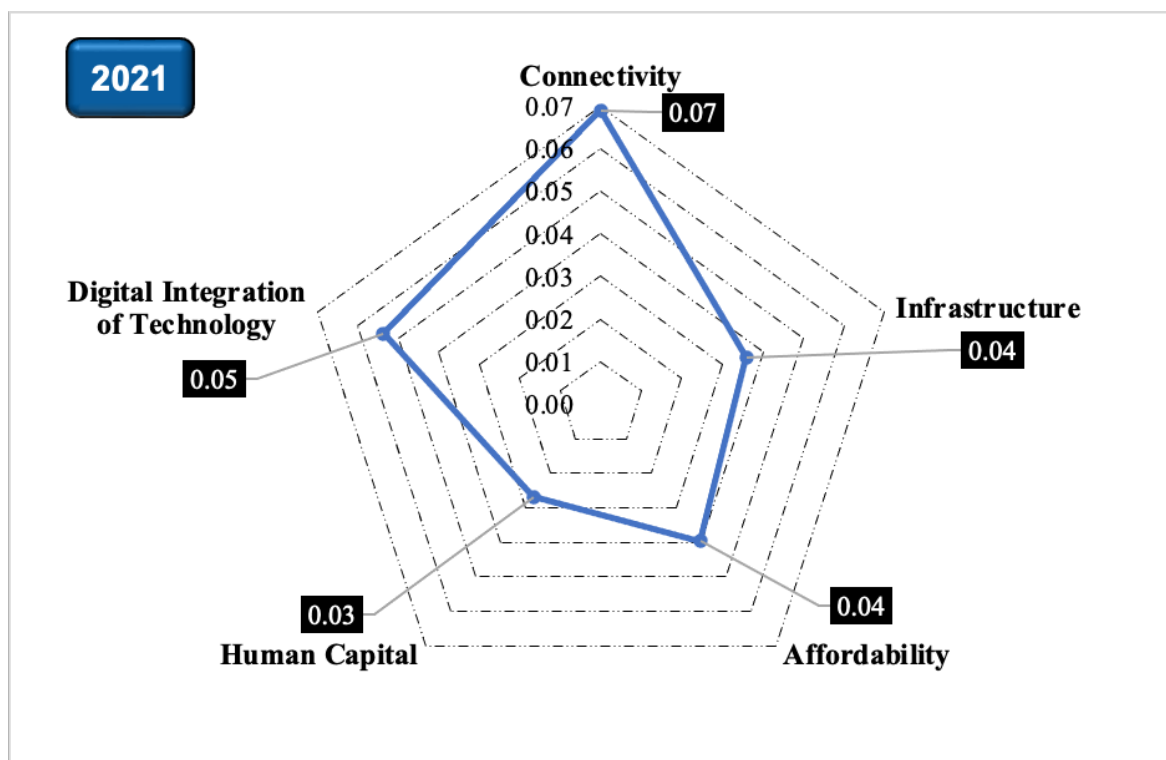


Figure 4.15: Dimensional Score of Laos DEPI from 2017-2021

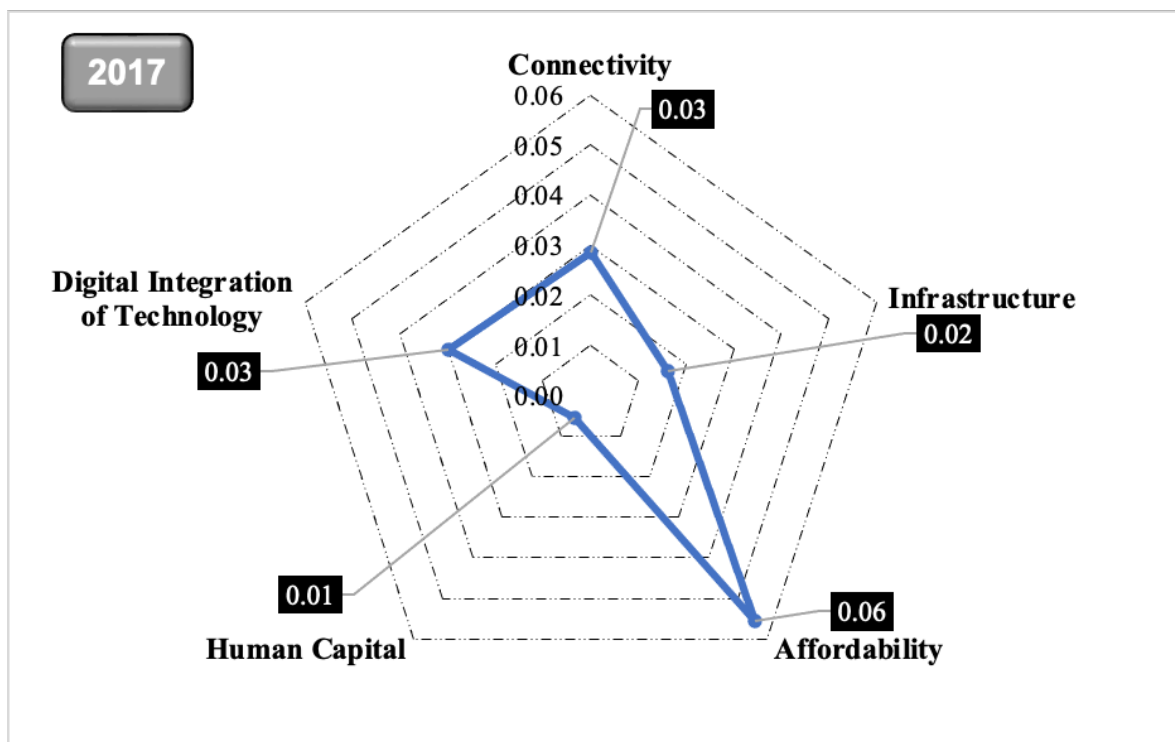
4.6.5 Myanmar

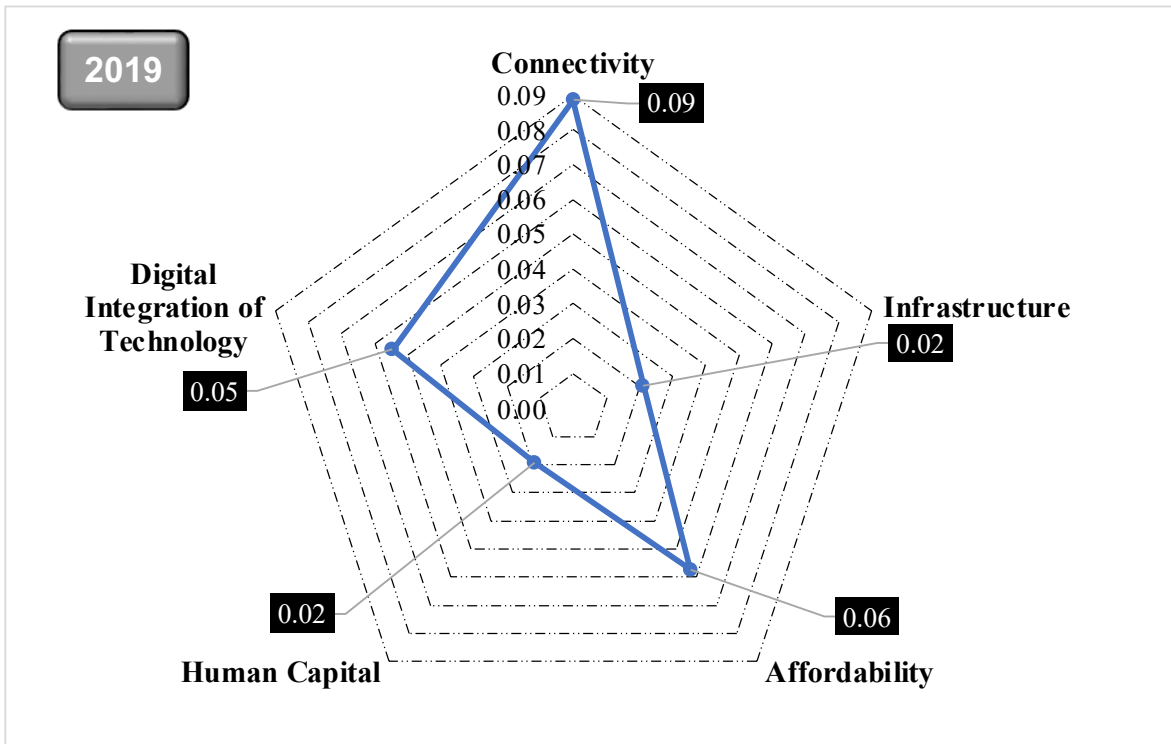
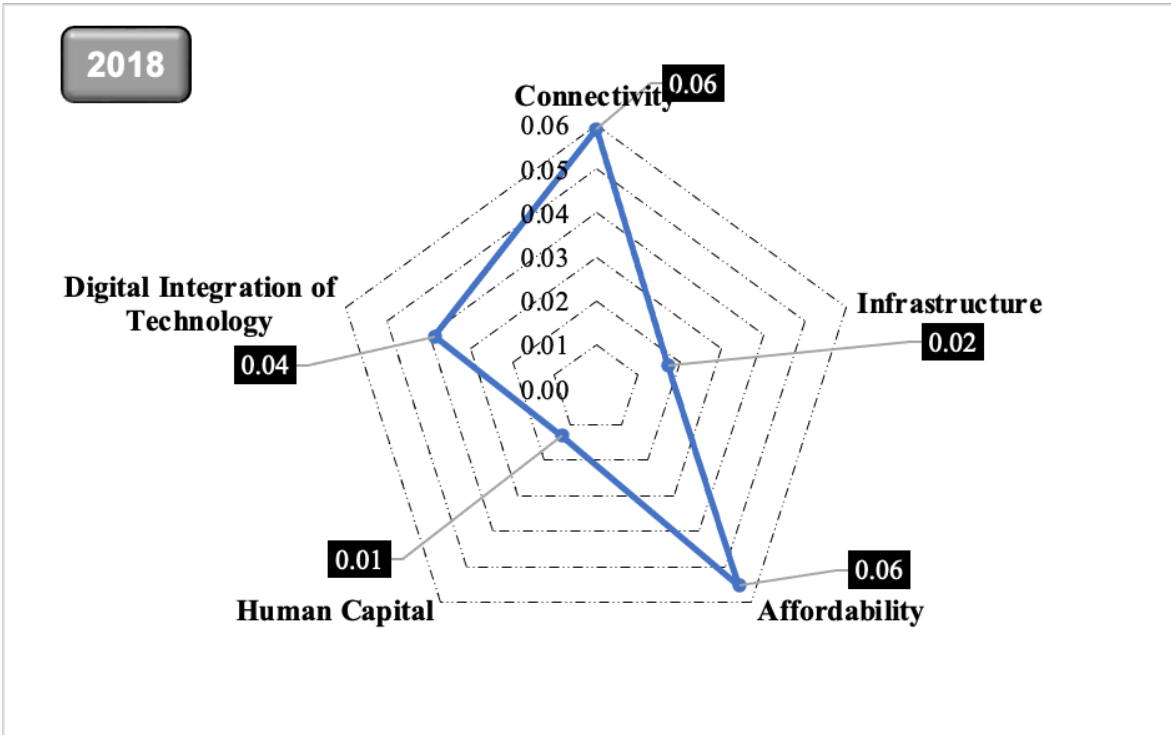
Myanmar has significant opportunities for advancement and catching up in various areas. The government is directing resources towards economic development and giving priority to advancing the digital economy through initiatives like the Myanmar Economic Resilience and Reform Plan (MERRP). This plan, expected to be a key blueprint for economic development from 2020 onward, aligns with digital government-related policies and regulatory frameworks such as cybersecurity, data protection, and e-commerce.

Efforts have been made to promote the integration of digital technology, with the COVID-19 economic relief package emphasizing the importance of digital payments. This has accelerated trends that were already underway before the pandemic, such as online company registration, tax payments, government college admissions, and applying for building permits.

However, human capital remains a significant challenge and an area in urgent need of improvement to fully unlock the country's digital economic potential. To address this, the Ministry of Education is collaborating with organizations like Ooredoo Myanmar and Google to conduct digital literacy and digital citizenship training nationwide. These efforts aim to enhance the skills and capabilities of both students and teachers in utilizing digital technologies.

The COVID-19 pandemic has acted as a catalyst for digital transformation in Myanmar, as in many other countries (IMF, 2021). However, the long-term success of these initiatives will depend on sustained investment in digital infrastructure and education (World Bank, 2021).





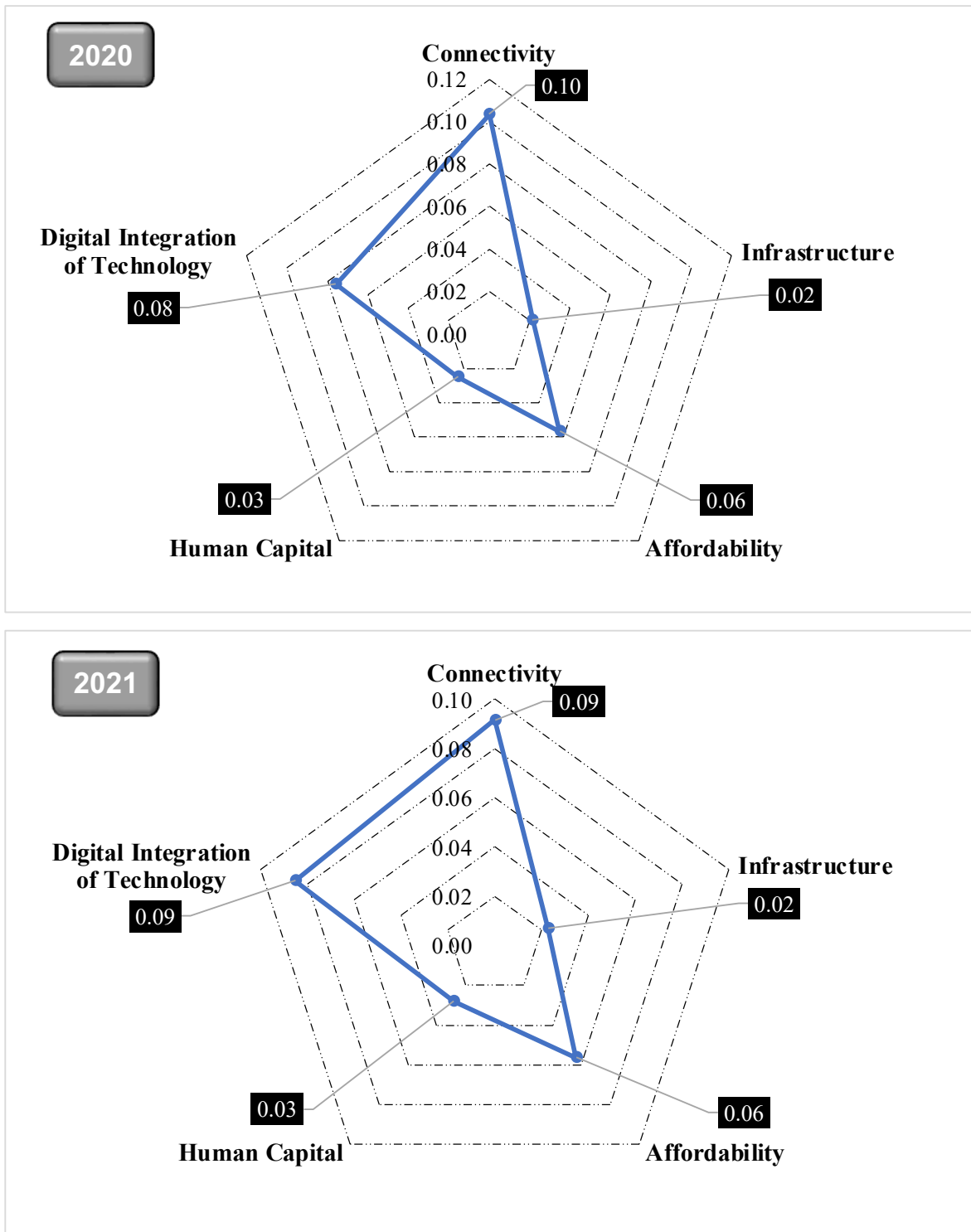


Figure 4.16: Dimensional Score of Myanmar DEPI from 2017-2021

4.6.6 Malaysia

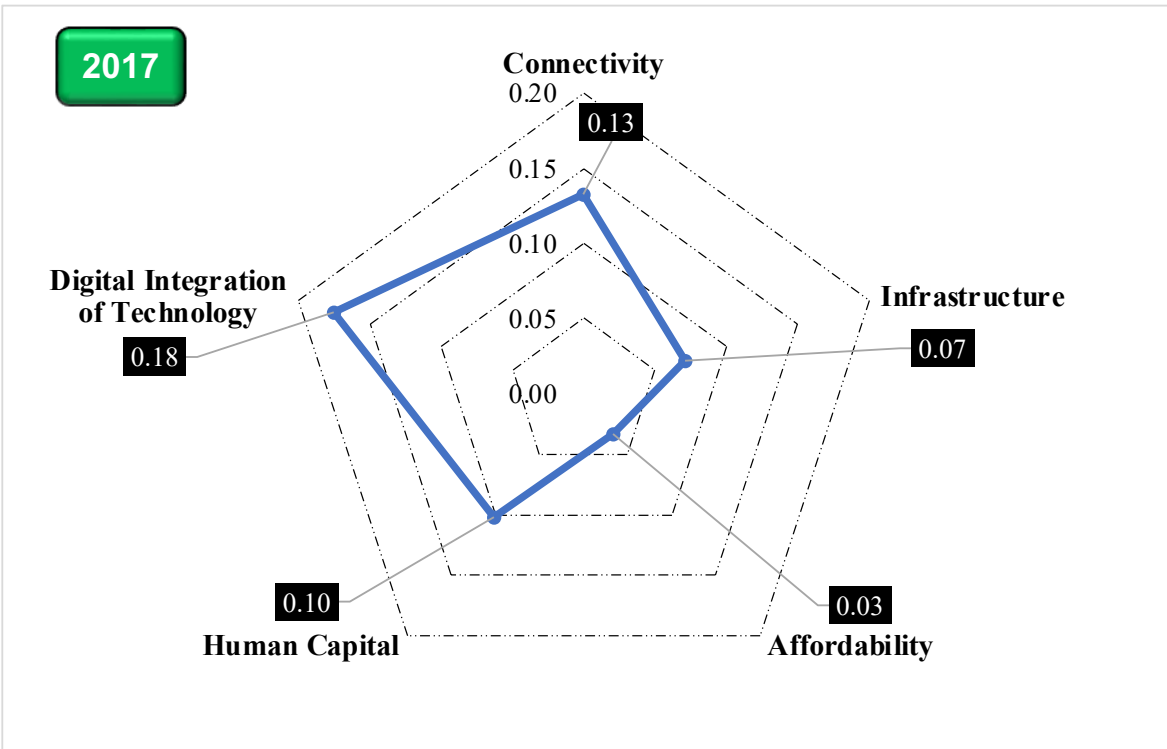
Studies over the years have shown that Malaysia achieves satisfactory results in all aspects except affordability, which is below satisfactory. Performance on the human capital front looks positive, but also points to the need for more to be done to develop capable talent to enable Malaysia to take full advantage of the digital integration of its digital economy. Subsequently, cultivating talent has become one of the crucial drivers of the Malaysia Digital Economy Blueprint (MyDIGITAL) released in February 2021, specifying 13 strategies to be implemented over the next five years.

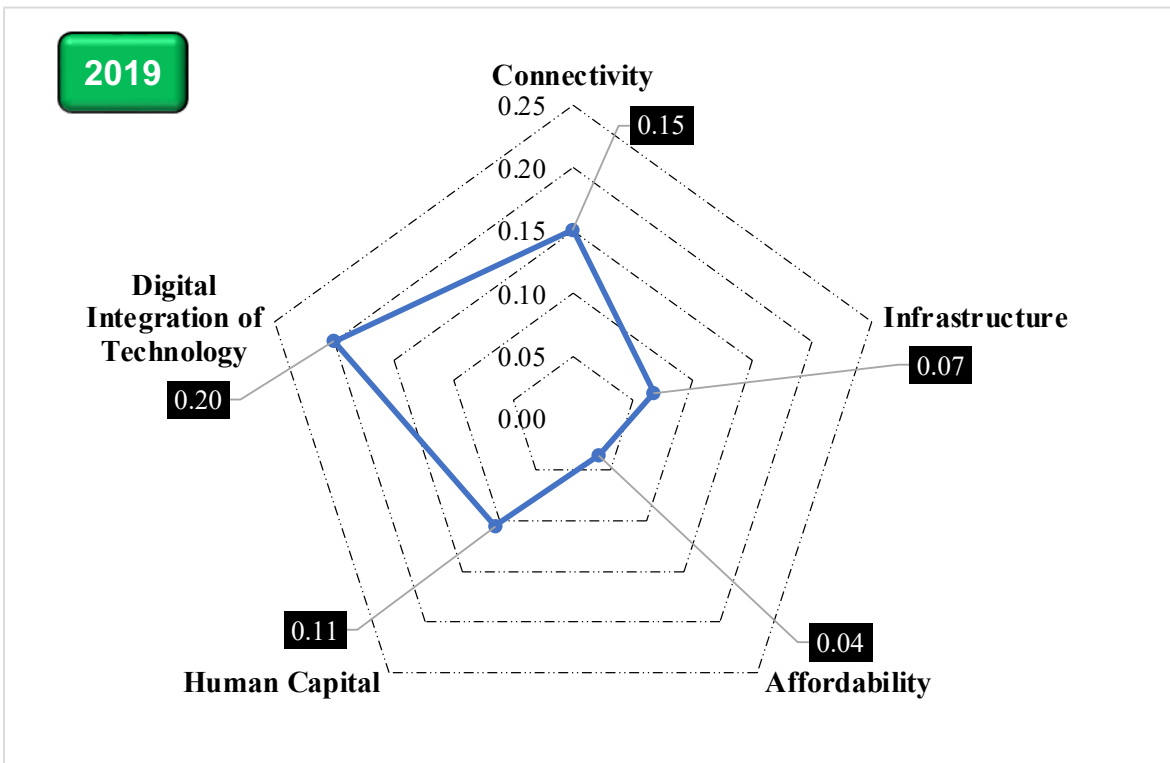
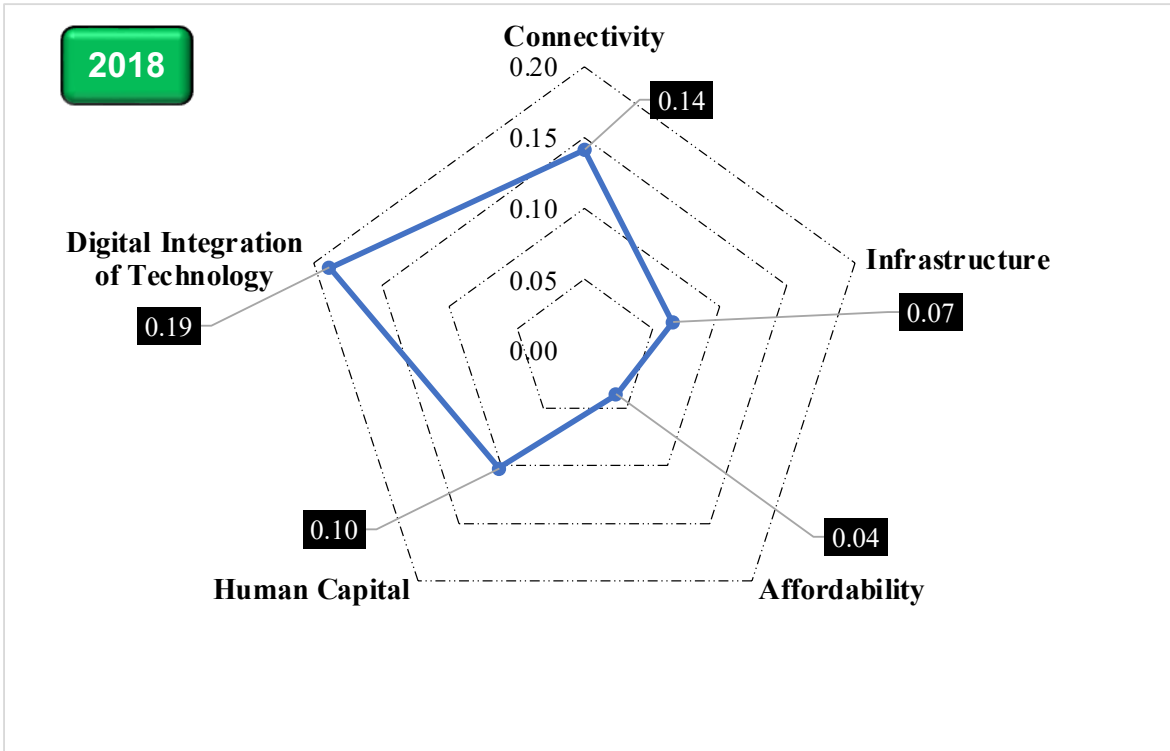
Efforts to promote the integration of digital technology in Malaysia have led to significant shifts in consumer behavior, with 70 percent now preferring retail stores that accept digital payments. The government, in collaboration with the central bank, Bank Negara Malaysia, has been actively fostering the development of electronic payment infrastructure and boosting public trust in digital transactions. Since 2017, Malaysia has initiated the Digital Free Trade Zone (DFTZ), aimed at facilitating cross-border trade for small and medium-sized enterprises and attracting e-commerce investment. Spearheaded by the Malaysia Digital Economy Corporation (MDEC), the DFTZ involves partnerships between government bodies, industry players, and e-commerce facilitators like Alibaba. Additionally, the Ministry of Communications and Multimedia (KKMM) has been tasked with overseeing the National Digital Identity (NDI) initiative, seeking feedback from citizens on its potential use across various sectors such as healthcare, financial services, e-commerce, pensions, and government online services.

In 2019, the government introduced the National Fiberisation and Connectivity Plan (NFCP) to bridge the digital gap by extending coverage and enhancing the quality of both fixed and mobile broadband services. In 2020, an allocation of RM3 billion was earmarked

to implement six NFCP initiatives. These initiatives are expected to foster an ecosystem benefiting various stakeholders including communication service providers, local contractors, equipment manufacturers, and solution providers. Over the five-year implementation period, approximately 20,000 new employment opportunities are projected to be generated. Furthermore, the government has dedicated RM20 million to accelerate the digitalization of government service delivery initiatives under the National Economic Recovery Plan (PENJANA), aligning with the objectives of the Public Sector ICT Strategic Plan.

Malaysia's focus on digital payments and e-commerce is in line with global trends, where digital transactions are becoming the norm (McKinsey, 2020). The DFTZ initiative is particularly noteworthy, as it positions Malaysia as a regional hub for e-commerce, similar to Singapore's role in the region (ASEAN Secretariat, 2019).





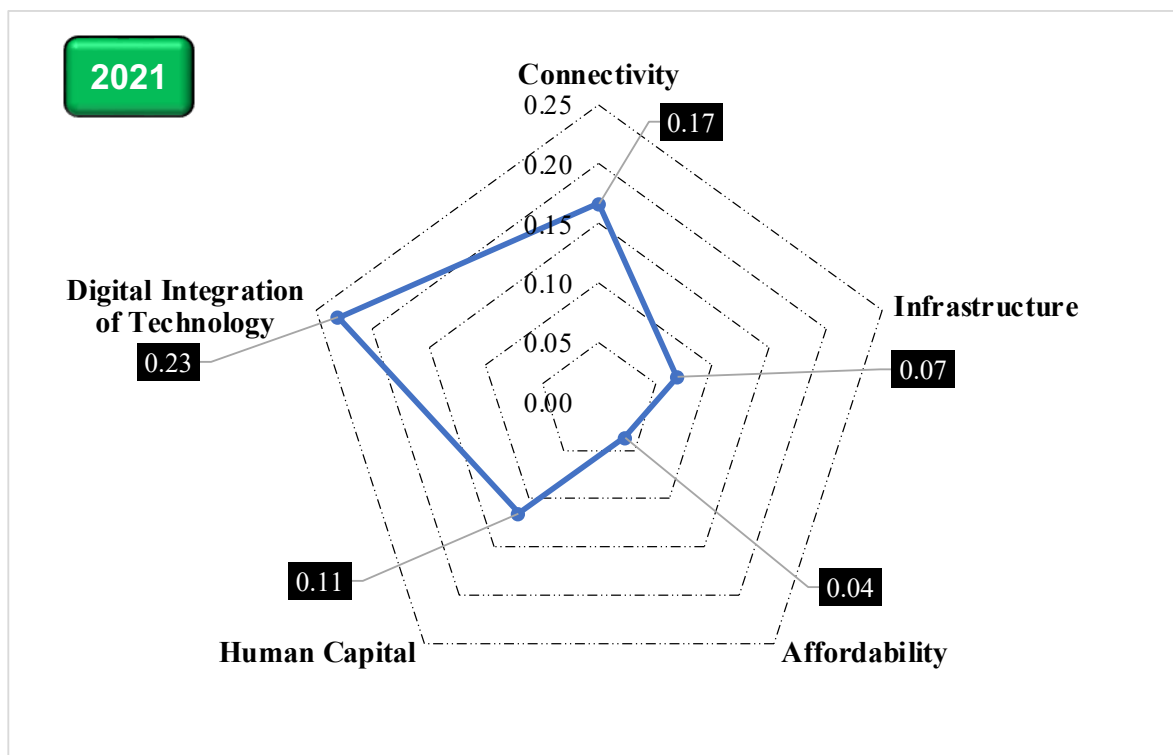
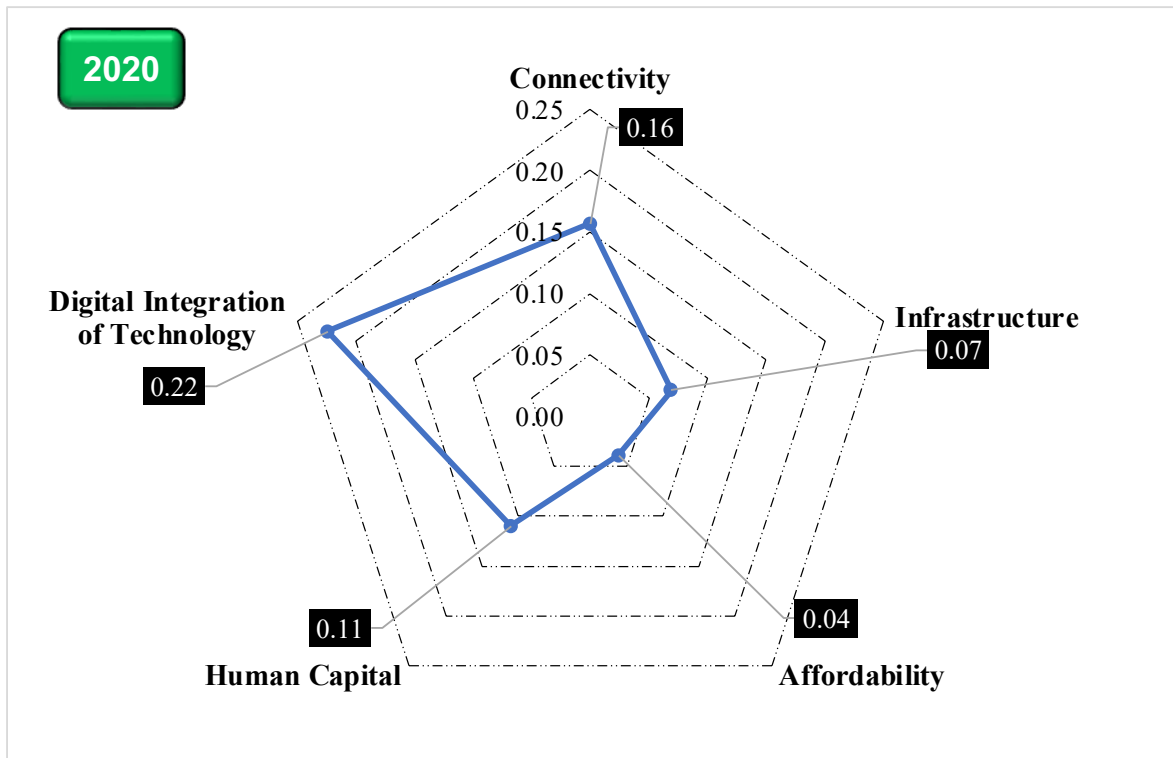


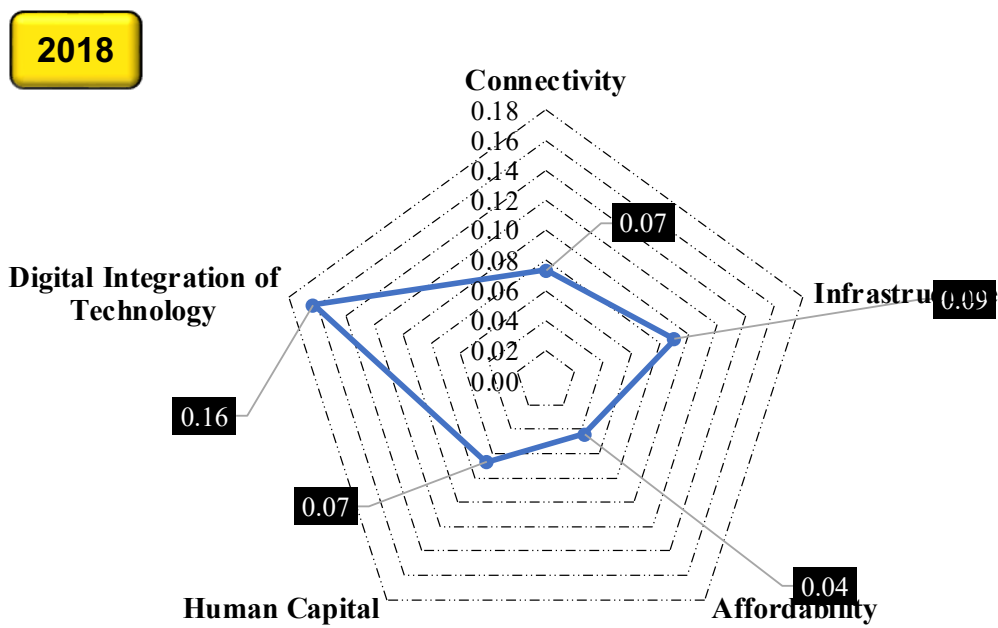
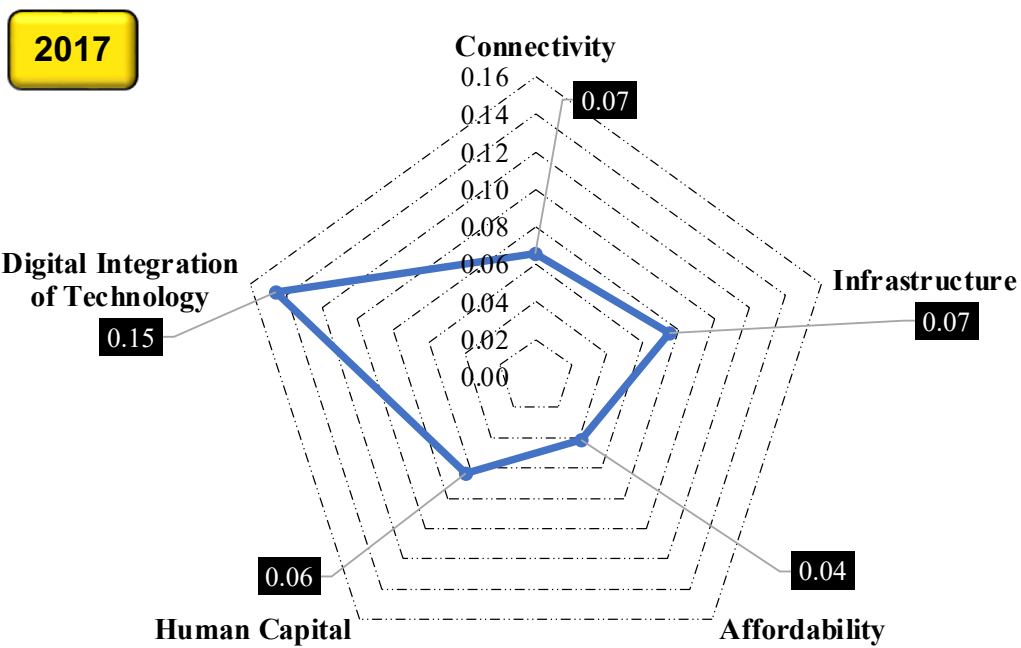
Figure 4.17: Dimensional Score of Malaysia DEPI from 2017-2021

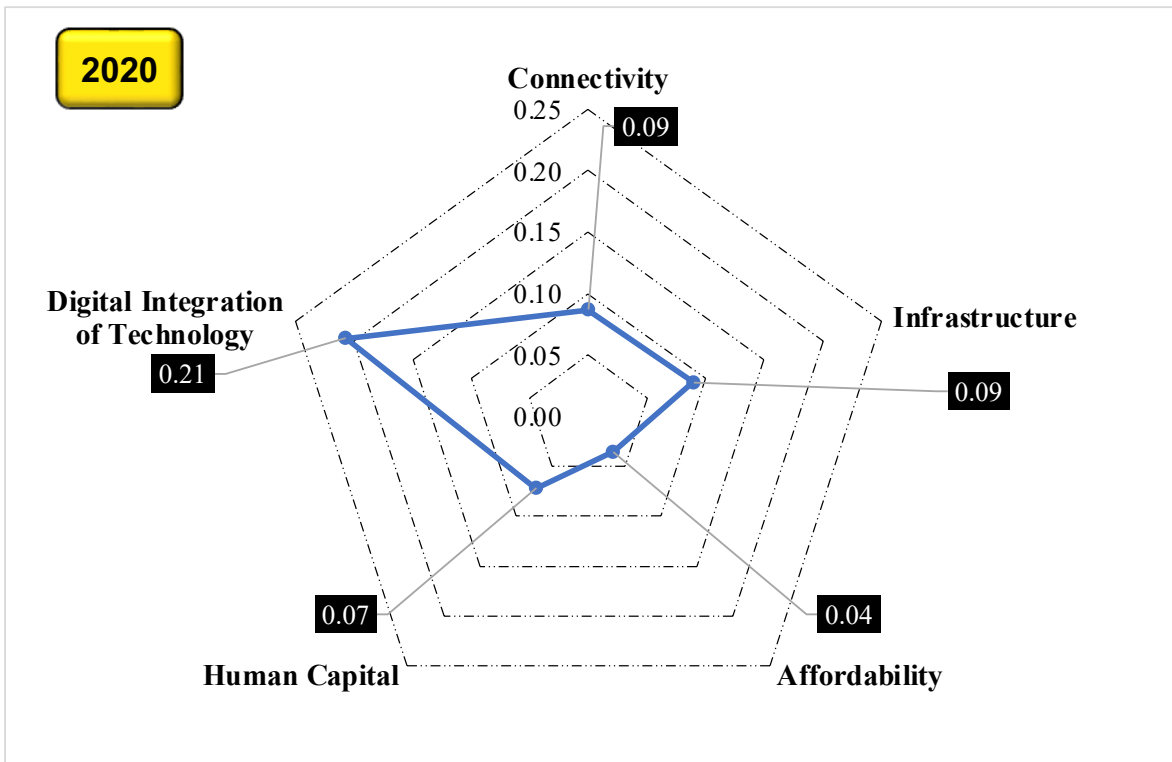
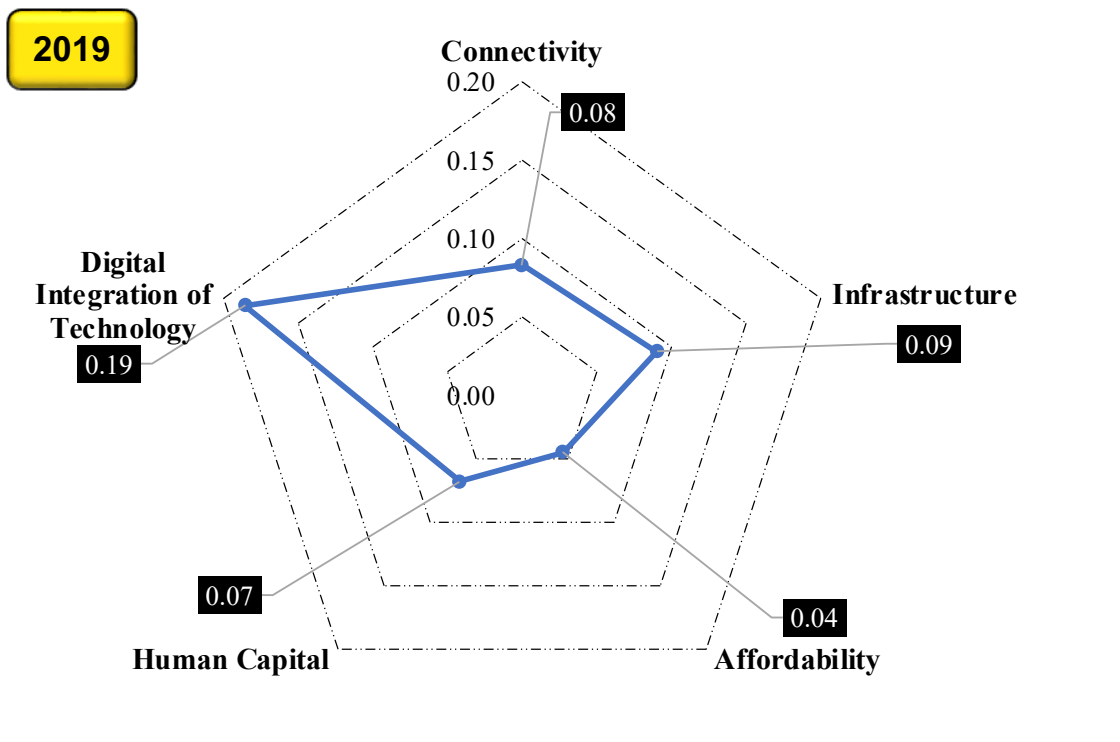
4.6.7 Philippines

In the Philippines, while legal frameworks for electronic transactions have been initiated, the adoption rate of digital payments and digital banking remains relatively low among the populace. There is a push towards enhancing digital services, particularly e-Government Payments, which serve as electronic platforms for citizens and businesses to settle taxes and other government charges. These platforms are intended to streamline tax collection processes, address tax evasion, establish audit trails, and enhance overall transparency within government financial transactions.

The government has introduced the Philippine Digital Workforce Competitiveness Act, aiming to enhance digital literacy and skills among the population. This initiative seeks to ensure that all individuals, irrespective of gender or age, have access to training programs for acquiring digital skills and competencies.

The slow adoption of digital payments in the Philippines can be attributed to a lack of trust in digital systems and limited access to digital infrastructure, particularly in rural areas (World Bank, 2021). The Philippine Digital Workforce Competitiveness Act is a step in the right direction, but its success will depend on effective implementation and sustained investment in digital education (UNESCO, 2020).





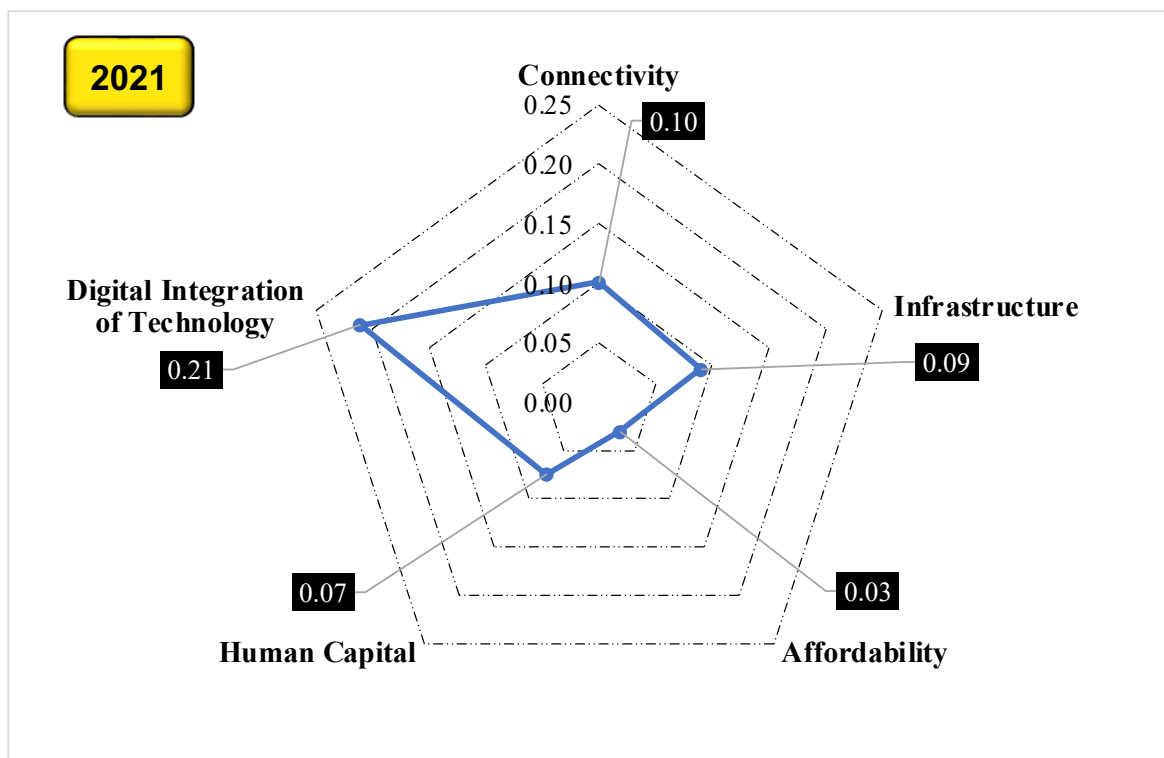


Figure 4.18: Dimensional Score of Philippines DEPI from 2017-2021

4.6.8 Singapore

Singapore has excelled in its DEPI across dimensions, consistently outperforming other Advanced Market Economies (AMS) over the study period. The Singaporean government's commitment to digital government processes is evident, including initiatives like modernizing procurement procedures to promote the adoption of government cloud services.

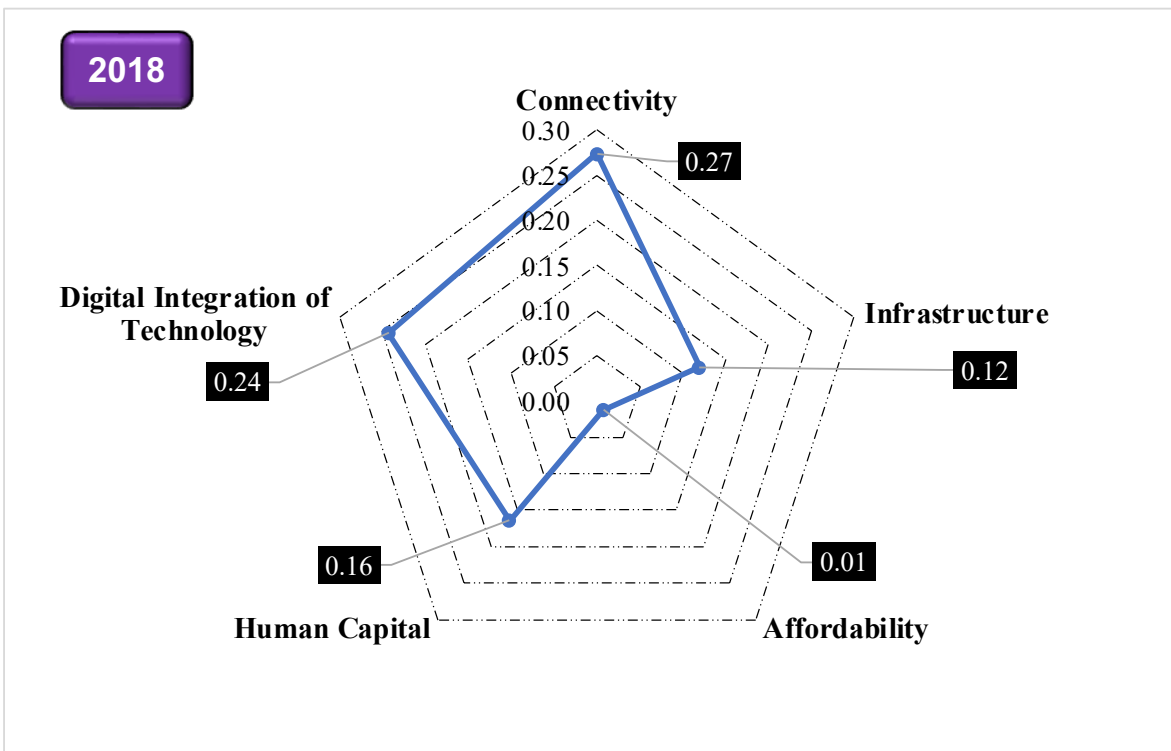
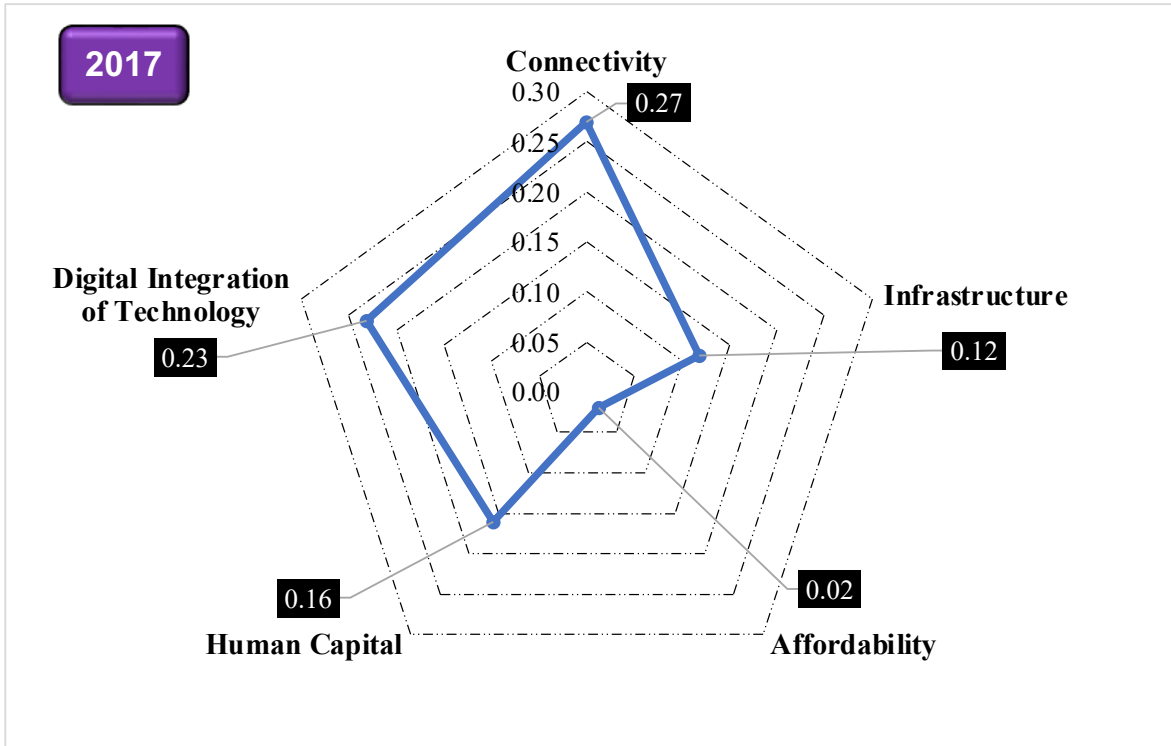
The 2018 Digital Readiness Blueprint by the Ministry of Communications and Information (MCI) outlines strategies for enhancing digital preparedness. In February 2021, President Halimah Yacob launched the Digital for Life Movement, aimed at supporting grassroots initiatives to co-create solutions that enable all Singaporeans to leverage digital technologies, acquire digital skills, and bridge the digital gap. This movement is part of a broader national endeavor to collaborate across various sectors to promote digital literacy,

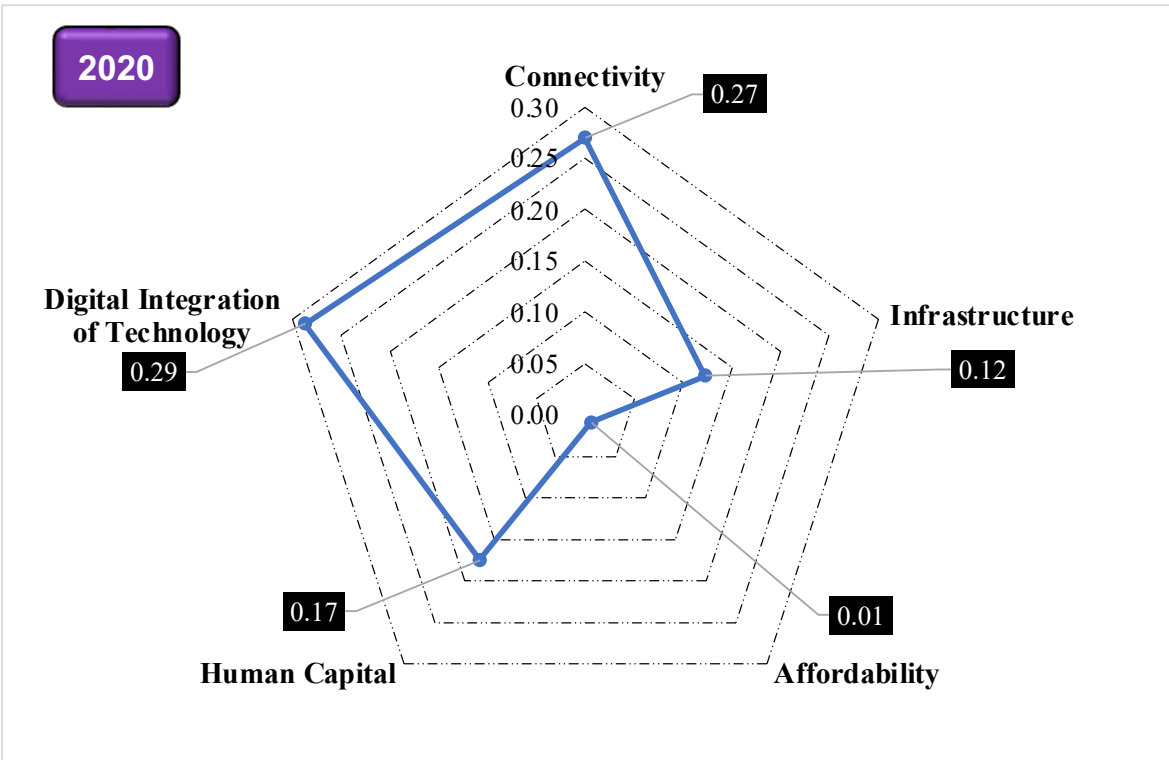
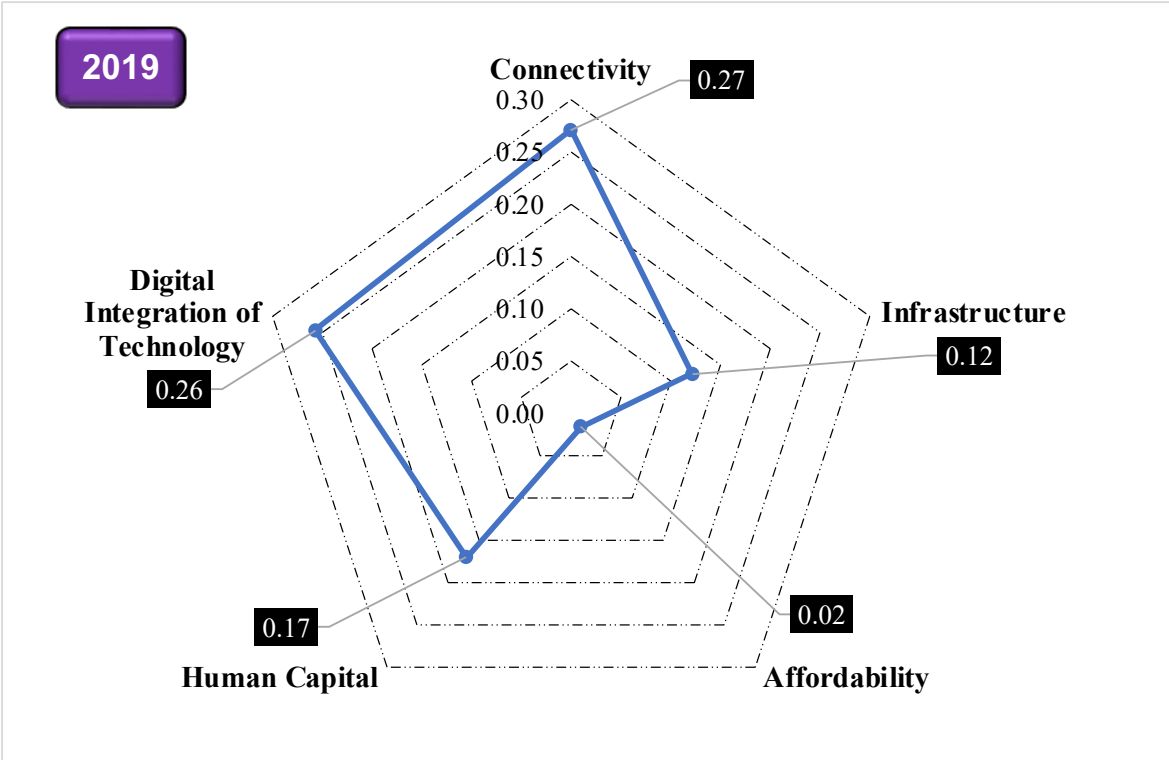
cyber wellness, and equitable access for all citizens. To enhance digital literacy and cultivate a skilled digital workforce, the Infocomm Media Development Authority (IMDA), in partnership with the Ministry of Education and industry/community stakeholders, has introduced programs to offer students opportunities to develop coding and computational thinking skills.

Apart from expanding the talent pool in universities, which has tripled in recent years, the government has introduced various continuing education training programs. One notable initiative is the Tech Skills Accelerator company-led training programs, where the government collaborates with industry players to enhance the tech talent pool in Singapore. This initiative aims to generate 6,250 job opportunities within the next two years.

Singapore's open economy and favorable business environment have attracted investment and encouraged global companies to establish their presence, facilitating knowledge and technology transfers. Concurrently, the government's emphasis on digital initiatives and widespread technological adoption fosters a supportive environment for companies and organizations to innovate and create novel solutions.

Singapore's success in digital transformation is often attributed to its strong governance and strategic planning, which have enabled it to stay ahead of global trends (Lee et al., 2019). The Digital for Life Movement is a prime example of how Singapore is addressing the digital divide, ensuring that all citizens benefit from digital advancements (World Bank, 2021).





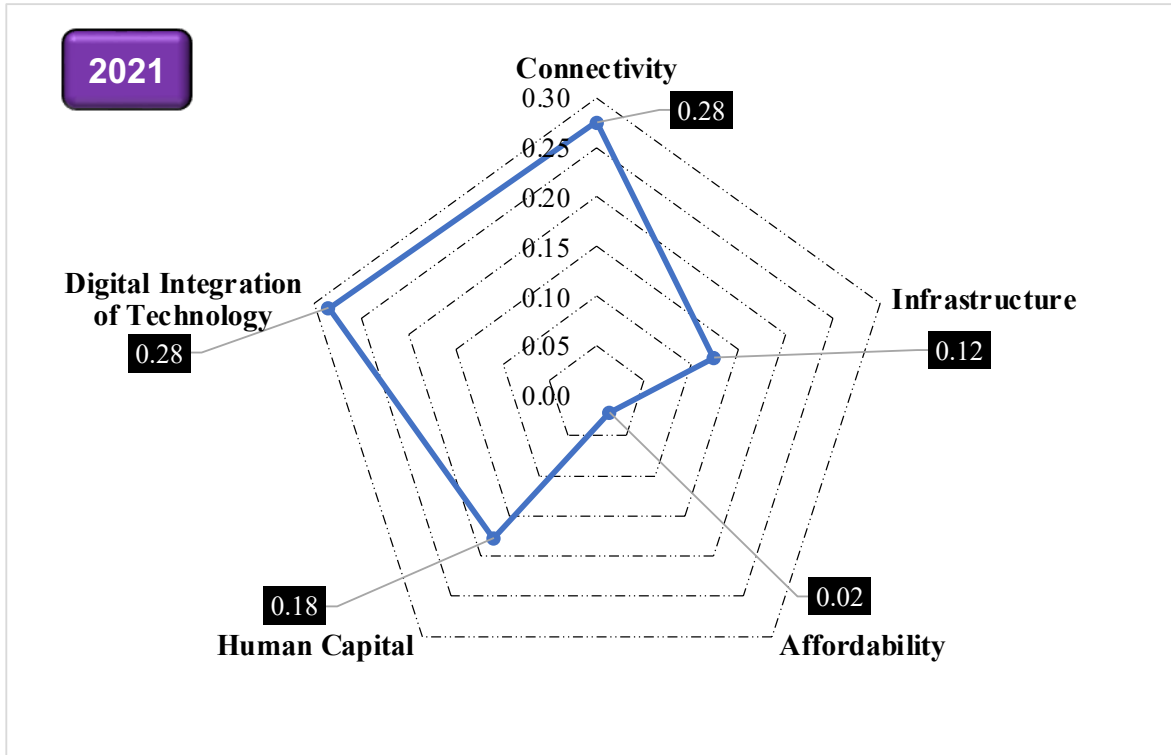


Figure 4.19: Dimensional Score of Singapore DEPI from 2017-2021

4.6.9 Thailand

Thailand performs strongly in its DEPI efforts with the majority of its dimensions performing good except more room for improvement in the dimension of affordability.

Since 2018, Thailand has implemented the 20-year Digital Economy and Society Development Policy, aiming to promote the adoption of digital technology across various sectors such as infrastructure, innovation, information, and workforce development. This national policy is geared towards advancing economic and social development on a national scale. Additionally, in October 2019, Thailand introduced the Digital Government Development Roadmap 2020-2022, which aims to integrate digital technologies into government operations and services. This roadmap builds upon previous plans and introduces new priorities such as facilitating data exchange among government agencies, utilizing open government data, supporting digital businesses, and enhancing public

participation through digital platforms. Aligned with the Digital Government Act, this roadmap sets the goal of achieving full digitalization of all government services by 2022.

In June 2018, the Thai government commenced development on the National Digital Identity (NDID) platform to enhance digital transactions and mitigate e-payment fraud. Currently, the NDID is primarily utilized for customer verification within the financial services sector, but there are plans to expand its application to cover legal entities and government sectors. Regarding digital payments, PromptPay was introduced in 2016 through collaboration between the government and the Bank of Thailand to establish a unified digital payment infrastructure accessible via mobile devices and online platforms. By May 2021, PromptPay had garnered 57.7 million user registrations, with daily transactions averaging 22.8 million.

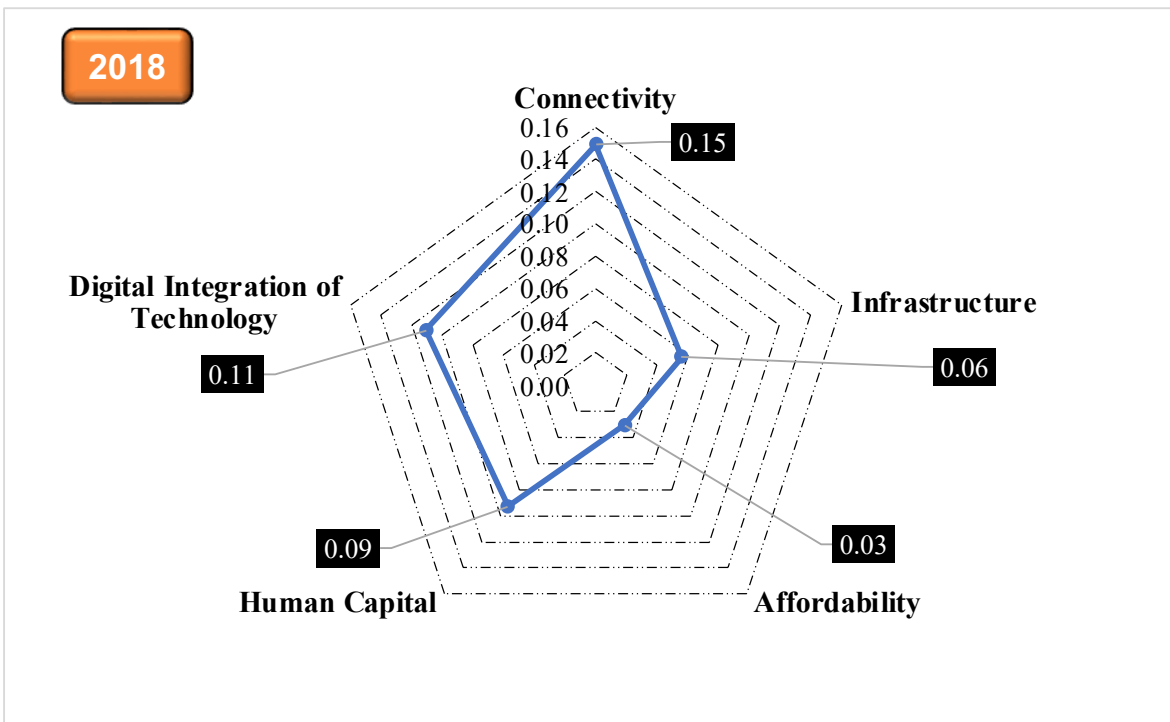
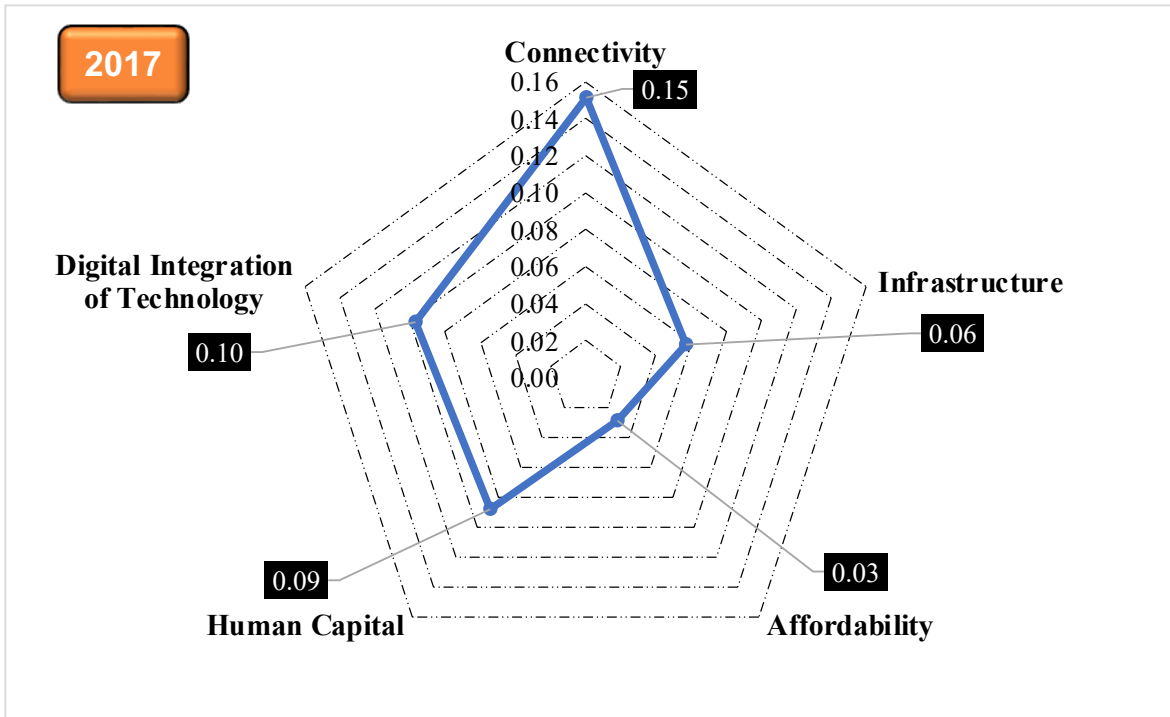
However, Thailand still faces significant challenges in human capital development as it navigates its digital transformation journey. The government must prioritize efforts to upskill the workforce for the challenges of the Fourth Industrial Revolution (IR4.0) to ensure they can meet evolving labor demands. To address this, the Digital Economy Promotion Agency (DEPA), established in 2017, is playing a crucial role. DEPA's responsibilities include fostering digital innovation and promoting the development of future skills like coding. Collaborating with various agencies, DEPA organizes training programs to bridge the skills gap among workers, students, and the elderly. Furthermore, DEPA has initiated the Digital Startup Fund, offering angel funding to startups across different sectors, thereby fostering the growth of the local startup ecosystem.

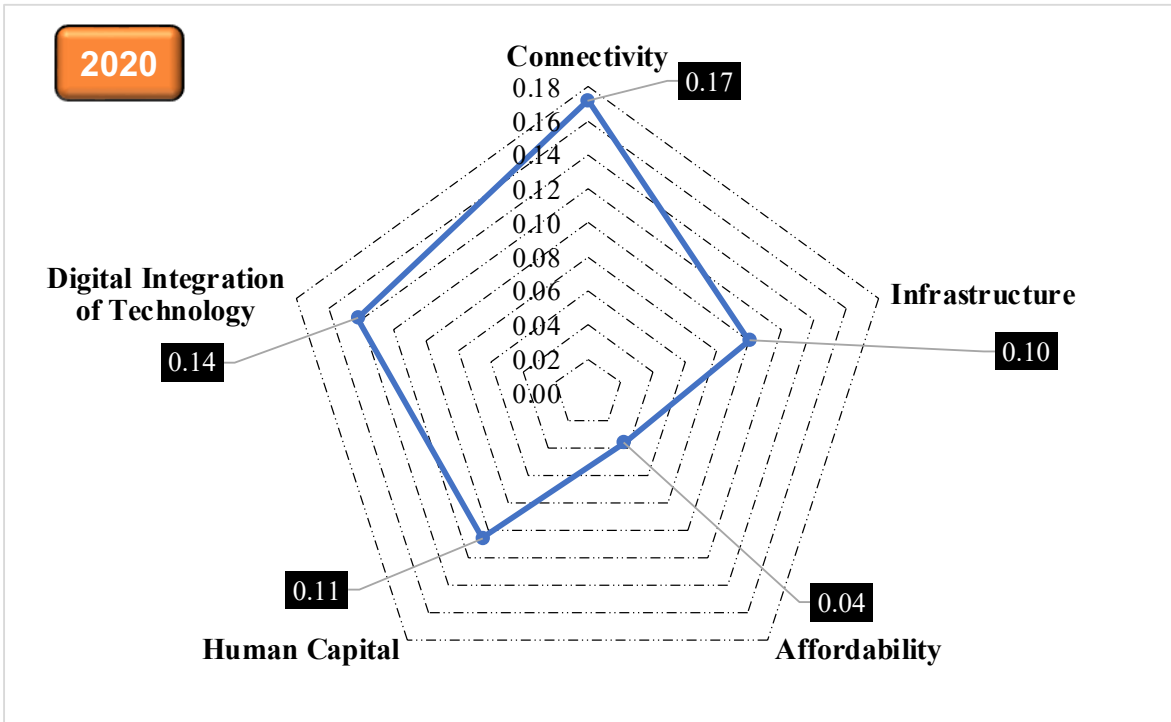
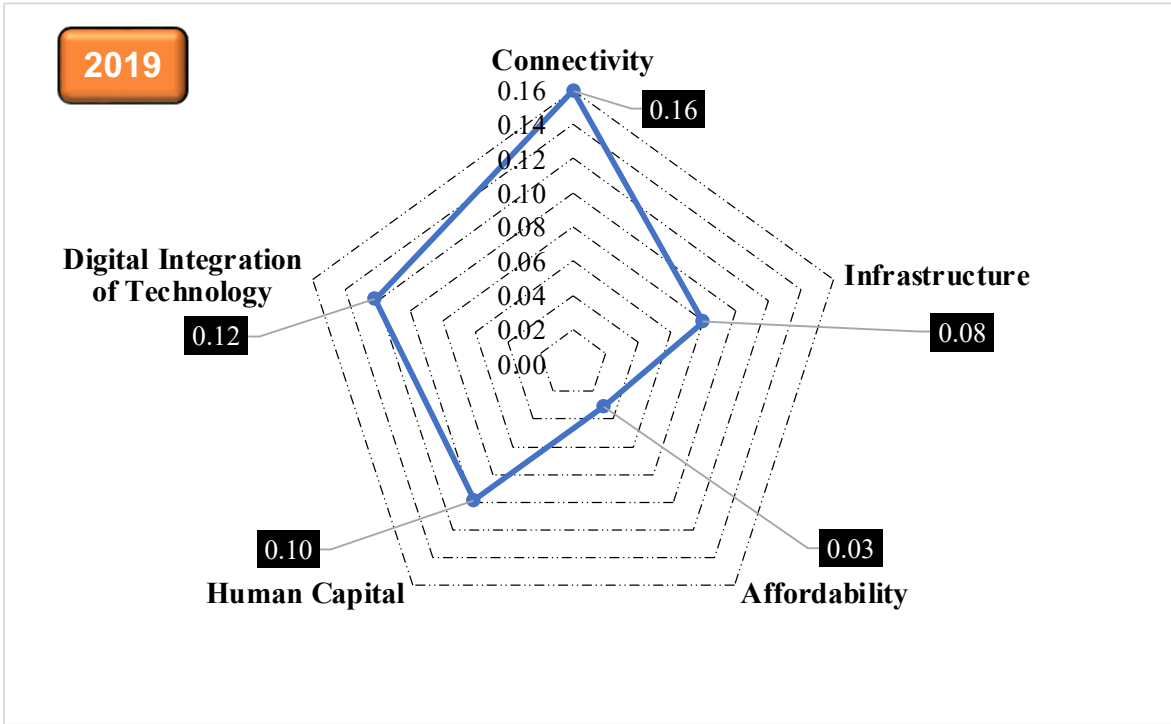
Digital skills are essential for driving innovation and entrepreneurship, and the Ministry of Digital Economy and Society (MDES) has surpassed its target of training over one million individuals to promote ICT usage and enhance digital literacy through the Net

Pracharat project. As part of this initiative, the expansion of broadband networks has provided internet access to rural villages in Thailand, accompanied by digital literacy training for residents. This training followed a three-step approach: initially, 1,033 trainers were trained, who then educated 100,466 community leaders. These community leaders subsequently trained villagers, resulting in a total of 1,244,633 individuals benefiting from the program.

Building on the success of the Net Pracharat Project, MDES established the Digital Volunteer Network to support local community businesses and enhance quality of life through digital technology. This initiative aims to improve income levels, education quality, public health, agriculture, e-commerce, and access to government services. These programs, as part of the government's Digital Thailand transformation roadmap, not only equip the Thai population with essential digital skills but also empower them to apply their knowledge to innovate and develop entrepreneurial solutions within Thailand.

Thailand's focus on digital literacy and workforce development is crucial for its long-term economic growth, as digital skills are increasingly in demand globally (World Economic Forum, 2020). The Net Pracharat project is a commendable initiative, but its success will depend on sustained investment and effective implementation (UNESCO, 2020).





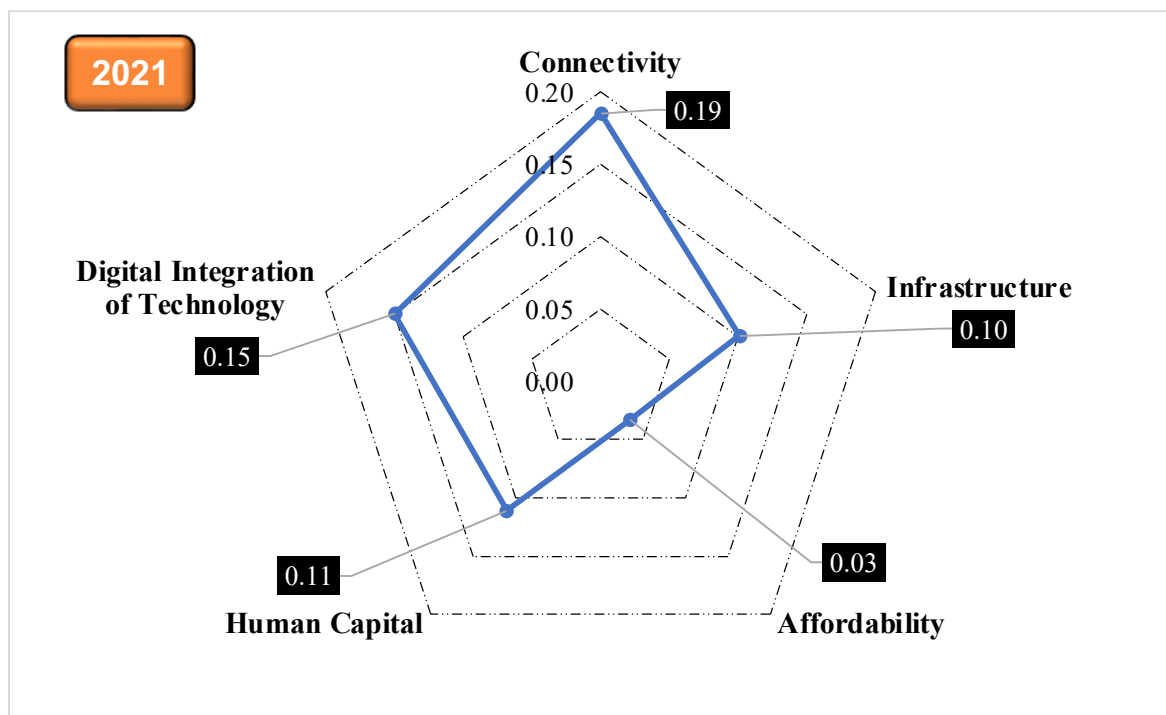


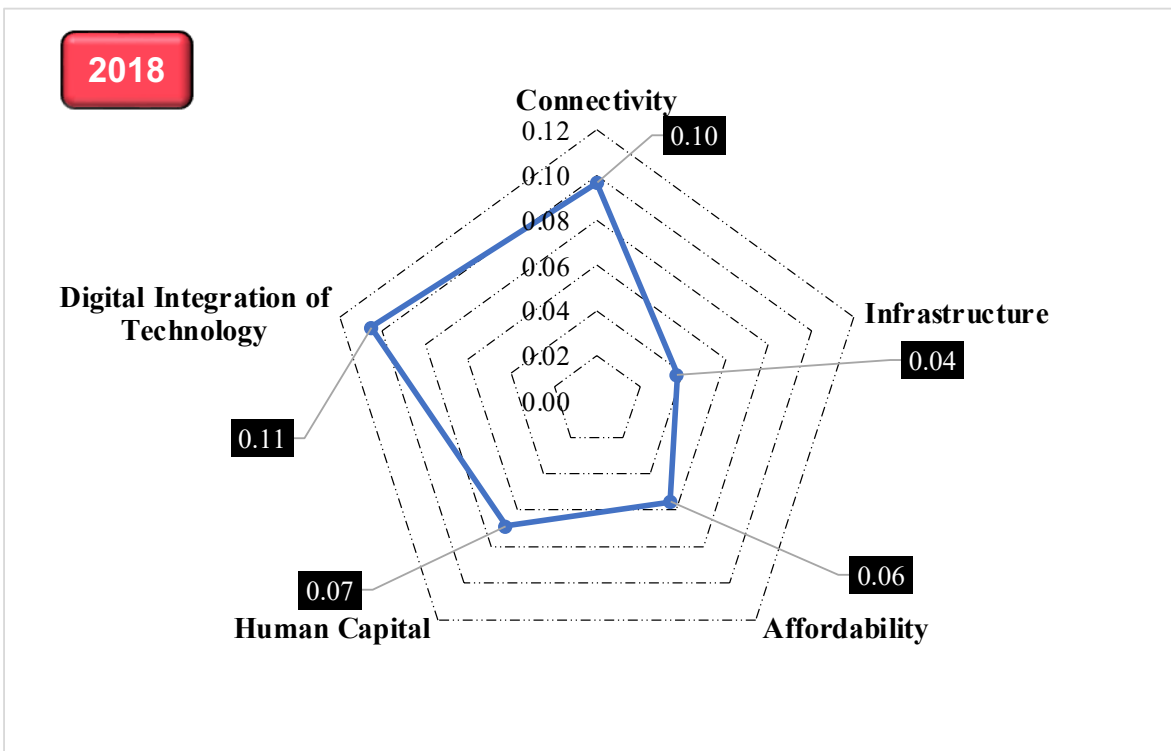
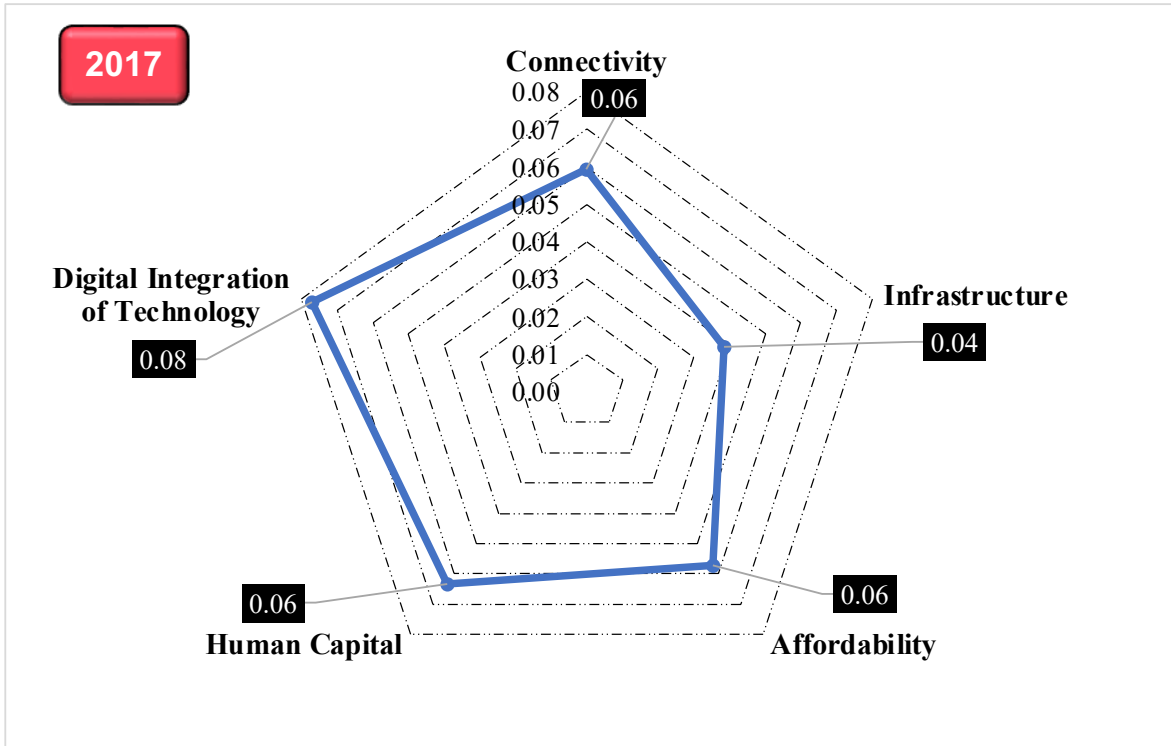
Figure 4.20: Dimensional Score of Thailand DEPI from 2017-2021

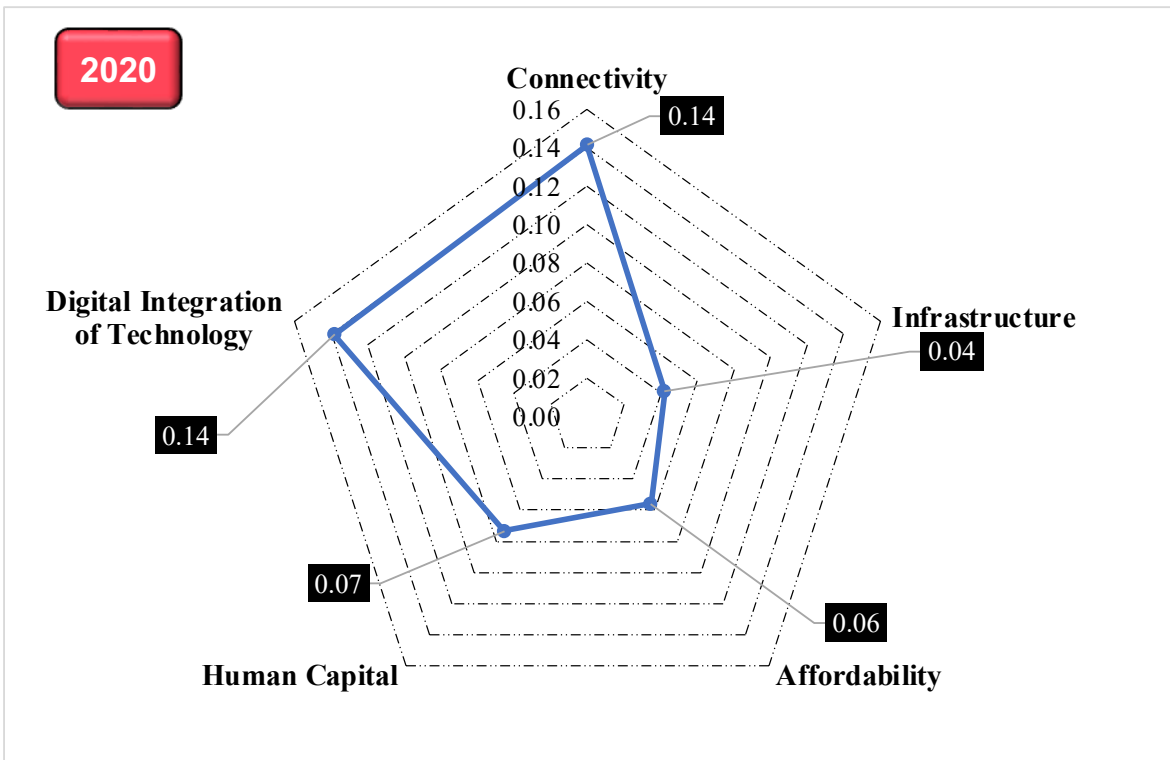
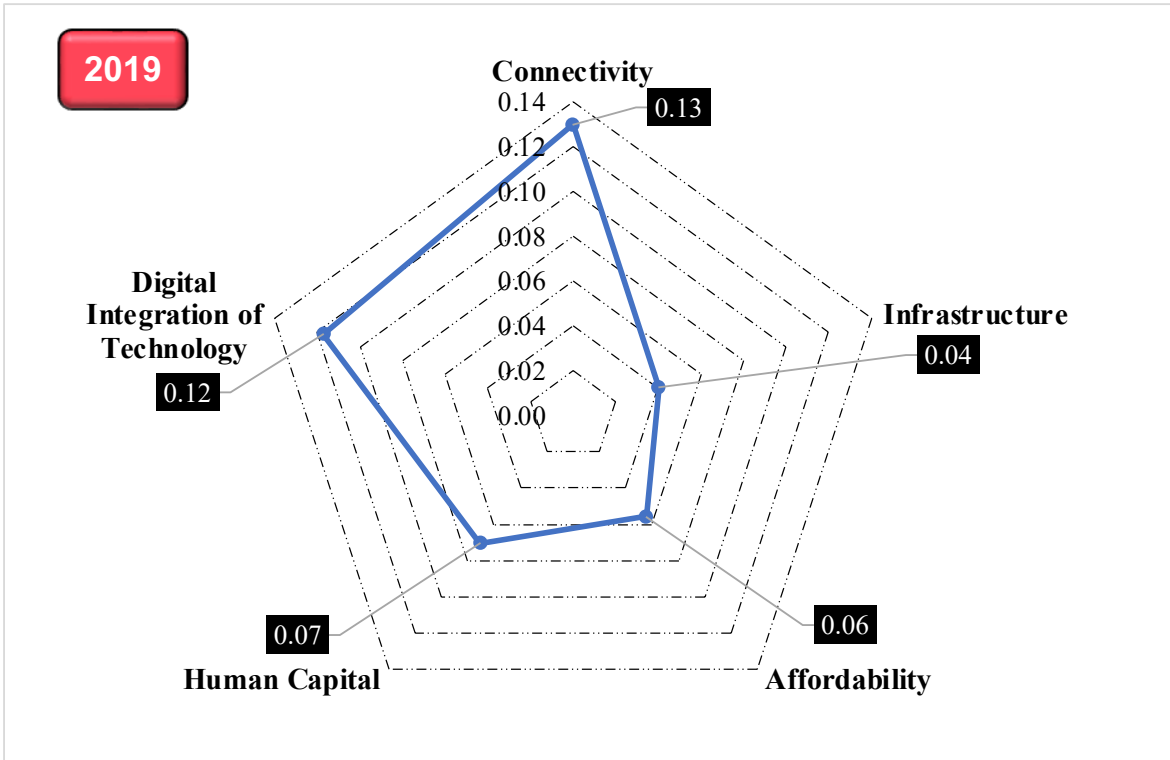
4.6.10 Vietnam

Vietnam demonstrates a commendable performance in its Digital Economy Performance Index (DEPI), with several dimensions showing moderate performance and consistent improvement over the years. The government has initiated plans to enhance capacity in STEM (Science, Technology, Engineering, and Mathematics) and digital skills as part of the overarching masterplan for Vietnam's digital transformation, outlined in Prime Minister's Decision No. 749/QD-TTg dated June 3, 2020, which lays out the National Digital Transformation Program up to 2025, with a vision extending to 2030. The Ministry of Information and Communication has put forth a draft proposal aimed at raising awareness and providing skills training to develop human resources for the national digital transformation up to 2025, with a vision towards 2030. The primary objectives are to ensure that Vietnamese agencies, organizations, and enterprises accelerate digital transformation by fostering digital transformation knowledge, digital skills, and technology adoption.

To ensure ongoing digital financial access for Vietnamese citizens and to bolster the security of digital transactions, the State Bank of Vietnam (SBV) has been consistently revising and improving its policies. The government is actively restructuring the economy to reshape the innovation ecosystem, which involves increasing state expenditures on science and technology and giving priority to firms investing in these fields. Moreover, there are concerted efforts to incentivize Vietnamese students and workers who have gained experience abroad to return home and contribute to the local tech community. However, progress has been slow due to regulatory complexities, with digital strategies spanning multiple disciplines and ministry silos. Therefore, there is a need for the government to enhance its coordination efforts across agencies and countries to facilitate interoperable e-government implementation. The COVID-19 pandemic has highlighted the urgency of accelerating these initiatives.

Vietnam's focus on STEM education is aligned with global trends, where countries are increasingly investing in science and technology to drive economic growth (OECD, 2020). However, the slow progress in regulatory reforms highlights the need for stronger governance and coordination, which are critical for successful digital transformation (World Bank, 2021).





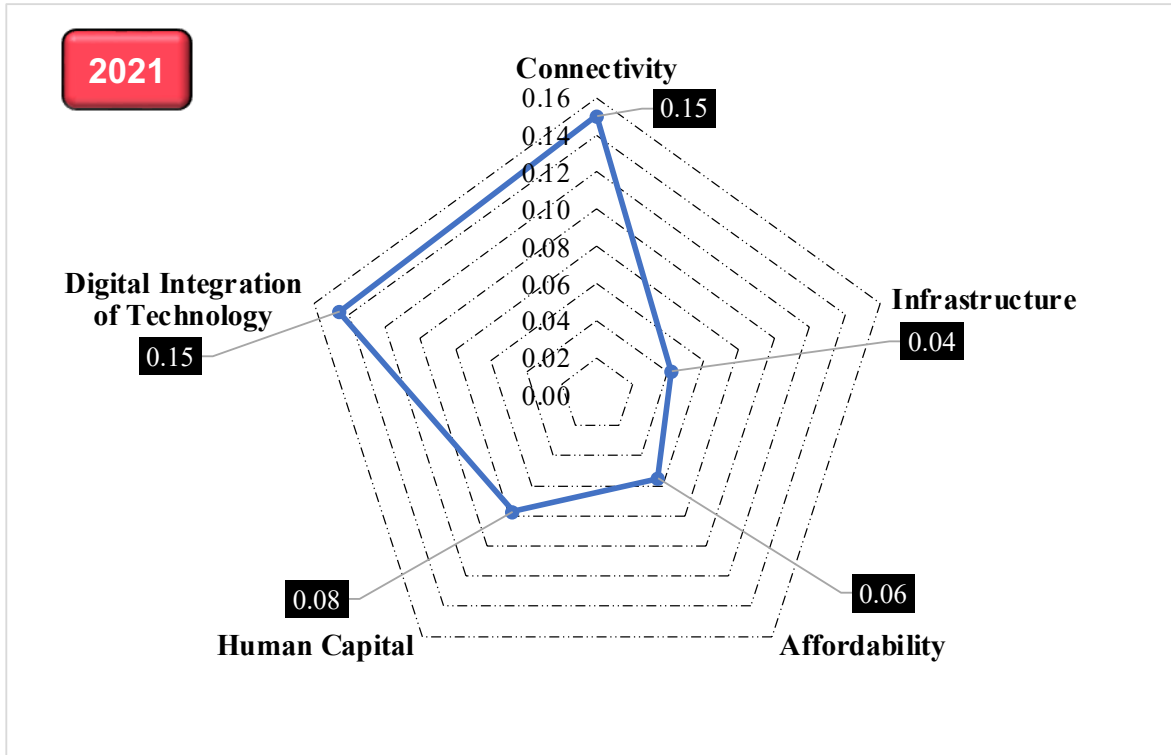


Figure 4.21: Dimensional Score of Vietnam DEPI from 2017-2021

4.7 Classification

The Digital Economy Performance Indicator (DEPI) aggregated score ranking highlights the varying degrees of digital economy development among ASEAN member countries. In year 2017, Singapore emerges as the frontrunner with a score ranging from 0.8 to 1.0, indicating a robust digital economy characterized by advanced technological infrastructure and high levels of digital adoption. Following closely is Malaysia, with a score falling between 0.5 and 0.8, showcasing significant progress in digitalization but with room for further enhancement. The remaining countries, including Thailand, Brunei, Philippines, Vietnam, Indonesia, Myanmar, Cambodia, and Laos, exhibit scores ranging from 0 to 0.5, indicating varying levels of digital economy development. These countries face challenges in terms of infrastructure, digital literacy, and regulatory frameworks, but they also present opportunities for growth and investment in the digital sector. Overall, the DEPI aggregated score ranking underscores the importance of continued efforts to advance digitalization

across the ASEAN region to realize its full economic potential in the digital age. The results for the year 2018 align closely with the DEPI aggregated score ranking in previous year, indicating consistent levels of digital economy development among ASEAN member countries during that period. Similarly, the results for the year 2019 mirror the Digital Economy Performance Indicator aggregated score ranking mentioned earlier, suggesting continuity in the digital economy development across ASEAN member countries for that year as well.

In the year 2020, there has been a notable shift in the DEPI aggregated score ranking among ASEAN member countries. While Singapore continues to lead with a score range of 0.8-1.0, both Malaysia and Thailand have shown improvements, now sharing the score range of 0.5-0.8. On the other hand, several countries, including Brunei, the Philippines, Vietnam, Indonesia, Myanmar, Cambodia, and Laos, have maintained their positions in the score range of 0-0.5. Potential reasons for this shift could include advancements in digital infrastructure, policy reforms to support digital innovation, increased investment in digital technologies, and initiatives to enhance digital literacy and skills development in Malaysia and Thailand. Conversely, other countries may have faced challenges such as limited resources, infrastructure constraints, or slower adoption of digital technologies, leading to stagnation or slower progress in their digital economy development.

The Digital Economy Performance Indicator aggregated scores for ASEAN member countries in 2021 reflect significant shifts compared to previous years. Singapore maintains its top position with a score range of 0.8-1.0, showcasing its continued dominance in digital economic performance. Notably, Malaysia, Thailand, Brunei, and the Philippines have all made substantial progress, now occupying the score range of 0.5-0.8, indicating advancements in their digital economies. Conversely, Vietnam, Indonesia, Myanmar,

Cambodia, and Laos have experienced declines in their scores, falling into the range of 0-0.5. These changes may stem from various factors such as differences in digital infrastructure development, policy initiatives, investment levels, and socioeconomic conditions across the region.

The shifts in DEPI scores highlight the dynamic nature of digital transformation in the ASEAN region. While some countries have made significant progress, others continue to face challenges, underscoring the need for regional cooperation and knowledge sharing to ensure inclusive digital growth (ASEAN Secretariat, 2019).

4.8 Chapter Remark

This chapter had managed to address and answer the specific objectives of the study and following spells out the details:

Objective 1: To measure the level of digital development across key dimensions of the digital economy for each AMS using individual index scores, providing insights into the strengths and weaknesses of specific dimensions at the country level. The present provides detailed DEPI scores for each ASEAN Member State (AMS) across the five dimensions: connectivity, infrastructure, affordability, human capital, and digital technology integration. These scores are calculated using the entropy weighting method, ensuring an objective measurement of digital development. For example, the DEPI scores for Singapore, Malaysia, and other AMS are broken down by dimension, showing which dimensions are strong (e.g., Singapore's high scores in connectivity and digital integration) and which are weak (e.g., Myanmar's low scores in human capital and affordability).

The chapter includes heat maps (Figures 4.6 to 4.10) and dimensional score visualizations (Figures 4.12 to 4.21) that allow for a clear comparison of each country's performance across dimensions. This helps identify specific strengths and weaknesses within

each country. For instance, Brunei's high scores in human capital and digital integration are highlighted, while its moderate scores in affordability are noted as an area for improvement. Table 4.1 (Descriptive Statistics) and Table 4.2 (Entropy Evaluation of Variables) provide the statistical foundation for understanding the variability and importance of each dimension and indicator. This ensures that the DEPI scores are robust and reflect the true digital development levels of each AMS.

Objective 2: To construct an aggregated digital economy performance index that reflects the overall digital economy performance of each AMS, allowing for a holistic comparison of digital development across the region. The chapter presents the aggregated DEPI scores for each AMS from 2017 to 2021 (Figures 4.1 to 4.5 and Table 4.4). These scores are calculated by aggregating the weighted scores of all dimensions, providing a single metric to compare the overall digital economy performance of each country. For example, Singapore consistently scores the highest (0.80 to 0.88), while Myanmar and Lao score the lowest (0.14 to 0.28), reflecting the disparity in digital development across the region. The chapter also provides a ranking comparison of AMS based on their DEPI scores (Figure 4.11), showing how each country performs relative to others over time. This allows for a holistic comparison of digital development across the region. The analysis highlights the digital divide between high-performing countries (e.g., Singapore, Malaysia) and low-performing countries (e.g., Myanmar, Cambodia), addressing the study's goal of identifying regional disparities. The heat maps (Figures 4.6 to 4.10) visually represent the aggregated DEPI scores, making it easy to compare the overall digital performance of AMS across years. This visualization reinforces the findings and provides a clear picture of regional trends.

Objective 3: To classify AMS into distinct groups based on their aggregated digital economy performance index scores, enabling the identification of countries at similar levels

of digital development for benchmarking and regional policy coordination. The chapter classifies AMS into three tiers based on their DEPI scores: Strong Development ($0.8 \leq \text{DEPI} \leq 1.0$), Medium Development ($0.5 \leq \text{DEPI} < 0.8$), and Weak Development ($0 \leq \text{DEPI} < 0.5$). This classification is based on the methodology developed by Li et al. (2012) and Shen et al. (2015), ensuring a data-driven approach. For example, Singapore is classified as Strong Development, Malaysia and Thailand as Medium Development, and Myanmar, Lao, and Cambodia as Weak Development. The classification allows for benchmarking of countries at similar levels of digital development. For instance, Malaysia and Thailand can be compared to identify best practices and areas for improvement, while Myanmar and Cambodia can focus on closing the gap with other AMS. The chapter also discusses the policy implications of these classifications, suggesting targeted interventions for countries in each tier. For example, high-performing countries like Singapore should focus on maintaining their lead, while low-performing countries like Myanmar need to prioritize infrastructure and human capital development. The chapter analyzes the trends in DEPI scores from 2017 to 2021, showing how countries have progressed over time. This helps identify which countries are making significant strides in digital development and which are lagging behind. For example, Indonesia and Vietnam show rapid growth in their DEPI scores, indicating strong progress in digital transformation, while Myanmar and Lao show slower progress, highlighting the need for more focused efforts.

In short, this study manage to effectively address all three objectives of the study by:

- i. Providing detailed DEPI scores for each AMS across dimensions, allowing for an analysis of strengths and weaknesses (Objective 1).
- ii. Constructing an aggregated DEPI index that enables a holistic comparison of digital development across the region (Objective 2).

- iii. Classifying AMS into distinct groups based on their DEPI scores, facilitating benchmarking and policy coordination (Objective 3).

The use of visualizations, heat maps, and trend analysis further reinforces the findings, ensuring that each objective is thoroughly answered and supported by data.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The importance of accurately measuring the Digital Economy has been increasingly recognized by ASEAN and the broader statistical community. Given its impact on various policy domains, this need has become more pronounced over the last decade. One major obstacle has been the absence of a universally agreed-upon definition of the Digital Economy. The diversity of regions, countries, and developmental stages poses challenges in defining the Digital Economy uniformly, resulting in varied estimations depending on the context.

While there is not a single comprehensive indicator or database that perfectly measures the digital economy, the DEPI, as outlined in this study, offers a means to assess the progression of the digital economy across AMS and reflect the impact of various policies and initiatives implemented thus far. However, the DEPI's effectiveness is contingent upon the availability and accuracy of data collected and regularly published by third-party sources. This may inadvertently constrain the updates that subsequent editions of the DEPI can track and assess. To improve progress tracking, AMS should consider aligning policies, regulations, and implementation efforts in priority areas that ASEAN and AMS can proactively measure. This will ensure ongoing relevance and utility of the DEPI and facilitate the implementation of current and future ASEAN initiatives.

Furthermore, the role of public-private partnerships cannot be overstated in driving the digital transformation. Collaborative efforts between governments and private sector players can accelerate the deployment of digital infrastructure and services, particularly in

underserved areas. By fostering innovation hubs and supporting digital entrepreneurship, ASEAN can create a vibrant ecosystem that sustains the growth of the digital economy.

In the vision outlined in the "ASEAN Digital Masterplan 2025" project, the upcoming two years hold the potential for significant progress in transforming the ASEAN region into both a digital economy and a digital society. A considerable number of people in ASEAN now possess broadband devices, be it fixed or mobile, and the utilization of cloud services could facilitate the delivery of innovative features at minimal cost. Additionally, the COVID-19 pandemic has underscored the benefits of digitally empowering various economic activities, prompting policymakers, regulators, and businesses to recognize the importance of digitalization. However, what exactly will this digital economy and society entail?

Firstly, it entails a society where every individual in ASEAN utilizes digital services to enrich their daily lives. This includes using digital platforms to connect with distant friends and family, for entertainment purposes, for conducting transactions, managing finances, making informed decisions, and accessing education and healthcare services.

Secondly, it involves AMS economies where businesses of all sizes leverage digital services to enhance productivity, streamline interactions within their value chains, and adopt innovative methods for consumer engagement. Furthermore, it entails public institutions offering a broader array of easily accessible and efficient services to ASEAN citizens.

Thirdly, it signifies a more prosperous ASEAN region, facilitated by the seamless and rapid trade enabled by digital services among AMS. This fosters the expansion of the most innovative and efficient businesses across the ASEAN region, resulting in a wider selection of affordable and high-quality products for all ASEAN consumers.

Lastly, it denotes an ASEAN economy poised for swift recovery from the COVID-19 pandemic in the coming years, aligning with the ASEAN Comprehensive Recovery Framework. This recovery is envisioned to be environmentally sustainable, promoting a greener and more sustainable long-term trajectory.

To achieve these goals, ASEAN must also prioritize the integration of emerging technologies such as artificial intelligence, blockchain, and the Internet of Things (IoT). These technologies have the potential to revolutionize sectors like healthcare, finance, and logistics, further accelerating the region's digital transformation. By investing in these areas, ASEAN can position itself as a global leader in digital innovation.

5.2 Policy Recommendations

The journey towards an ASEAN digital economy has been steady and enduring. Initiatives such as the E-ASEAN Framework Agreement in 2000 and the establishment of the ASEAN Digital Ministers' Meeting (ADGMIN) in 2019 highlight the bloc's commitment to steering the region towards a digitally empowered economy and society. The 2021 ASEAN Digital Masterplan (ADM 2025) marks a significant departure from the earlier ASEAN ICT Masterplan 2020 of 2015, evolving beyond mere declarations to include specific objectives and a vision for positioning the ASEAN region as a leading digital community and economic bloc. By focusing on the development of secure and transformative digital services, technologies, and ecosystems, ADM 2025 aims to drive the digital transformation beyond traditional information and communications technology. This shift is reflected in the renaming of the ASEAN vision from 'ICT cooperation' to 'digital cooperation', underscoring the political momentum of ASEAN member states and their commitment to accelerating digital advancement, encompassing standards, norms, and efforts to bridge the digital divide.

According to Okano-Heijmans et al. (2022), a notable distinction between the EU Digital Compass 2030 and ASEAN's ADM 2025 lies in the EU document's inclusion of specific numerical targets and secured funding, whereas ADM 2025 lacks such specificity and funding. This absence of concrete targets and funding poses a risk of the ASEAN Digital Masterplan falling short of its objectives. The lack of hard targets may be attributed to the voluntary nature of ASEAN programs, which are executed based on soft-target agreements among member states, without a mechanism for common budget allocation or resource transfer. Unlike the EU, ASEAN plans heavily rely on the efforts of individual member countries, which often lack coordination among themselves. Additionally, the coordination between ADM 2025 and individual member countries' strategies remains unclear, making it challenging to establish hard targets in the Digital Masterplan. Given the significant portion of the population lacking access to digital infrastructure and banking services, bridging the digital divide is a primary concern for most ASEAN governments, excluding Singapore.

To address these challenges, the following additional policy recommendations are proposed:

- i. **Establish Clear Numerical Targets and Funding Mechanisms:** ASEAN should adopt a more structured approach by setting specific, measurable targets for digital transformation, similar to the EU Digital Compass 2030. This includes defining key performance indicators (KPIs) for digital infrastructure, digital skills, and e-government services. Additionally, ASEAN should explore the creation of a regional digital transformation fund to support member states in achieving these targets, particularly for less developed countries.
- ii. **Enhance Regional Coordination and Governance:** ASEAN should strengthen the role of the ASEAN Digital Ministers' Meeting (ADGMIN) to ensure better coordination

among member states. This could involve creating a dedicated ASEAN Digital Transformation Office to oversee the implementation of ADM 2025, monitor progress, and facilitate knowledge sharing among member states.

- iii. **Promote Digital Skills and Literacy:** ASEAN should prioritize the development of digital skills across all levels of society. This includes integrating digital literacy into national education curricula, offering vocational training programs for workers, and providing incentives for businesses to upskill their employees. Special attention should be given to marginalized groups, such as women, rural populations, and the elderly, to ensure inclusive digital transformation.
- iv. **Accelerate the Deployment of Emerging Technologies:** ASEAN should actively promote the adoption of emerging technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) across key sectors like healthcare, finance, and logistics. This can be achieved through public-private partnerships, innovation hubs, and regulatory sandboxes that allow for experimentation and scaling of new technologies.
- v. **Strengthen Cybersecurity and Data Privacy Frameworks:** As digital services expand, ASEAN must prioritize the development of robust cybersecurity and data privacy frameworks to build trust among consumers and businesses. This includes harmonizing cybersecurity standards across member states, establishing regional cybersecurity response teams, and promoting awareness of data protection best practices.
- vi. **Foster Public-Private Partnerships (PPPs):** Governments should actively engage with the private sector to accelerate the deployment of digital infrastructure and services. PPPs can be particularly effective in extending connectivity to underserved areas and

developing innovative digital solutions. Incentives such as tax breaks and grants can encourage private sector participation in digital transformation initiatives.

- vii. **Improve E-Government Services:** ASEAN member states should invest in modernizing their e-government platforms to make them more user-friendly, efficient, and accessible. This includes digitizing public services, enabling cross-border digital identification, and promoting the use of digital signatures for official transactions.
- viii. **Encourage Cross-Border Digital Trade:** ASEAN should work towards harmonizing regulations and standards to facilitate seamless cross-border digital trade. This includes simplifying customs procedures, promoting the use of digital payment systems, and ensuring interoperability of digital services across member states.
- ix. **Support Digital Entrepreneurship and Innovation:** ASEAN should create an enabling environment for digital startups and SMEs by providing access to funding, mentorship, and market opportunities. This can be achieved through regional innovation hubs, startup incubators, and cross-border collaboration platforms.
- x. **Monitor and Evaluate Progress Regularly:** ASEAN should establish a robust monitoring and evaluation framework to track the progress of digital transformation initiatives. This includes regular reporting on KPIs, conducting impact assessments, and making data-driven adjustments to policies and programs as needed.

By implementing these recommendations, ASEAN can address the current gaps in its digital transformation efforts and ensure that the region remains competitive in the global digital economy. These measures will not only enhance the effectiveness of ADM 2025 but also contribute to the broader goals of economic growth, social inclusion, and environmental sustainability.

Nevertheless, there is no shortcut to fostering the digital revolution in the region, as emphasized in the ADM 2025 report, as depicted in Figure 5.1.

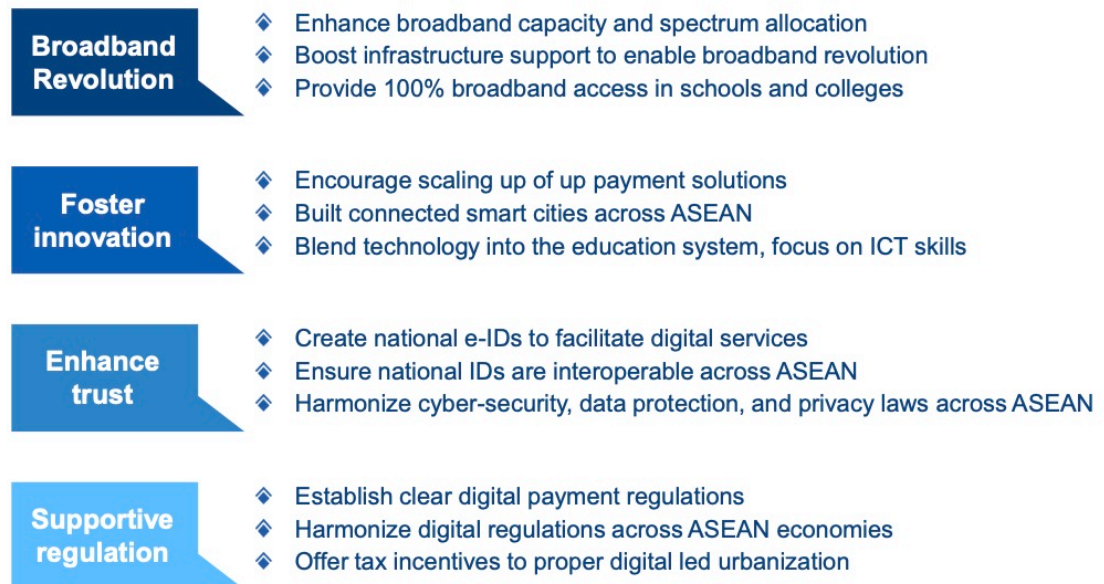


Figure 5.1: The Way Forward to Foster Digital Revolution in ASEAN

In summary, the ADM 2025 aims to shape ASEAN into a leading digital community and economic powerhouse, driven by secure and transformative digital services, technologies, and ecosystems. Achieving this vision necessitates collaborative efforts from governments, regulators, and market players. Market players should invest in new technologies, innovate services, and compete to deliver them to end users efficiently. Governments and regulators can contribute by removing unnecessary regulatory barriers, funding initiatives for digital inclusion and skills development, fostering trust in digital services, harmonizing regulations and standards across ASEAN, and promoting awareness of the value of digital services. High-quality and widespread connectivity across ASEAN is crucial, requiring improvements in existing infrastructure and extending connectivity to underserved areas.

The connectivity infrastructure must support services that are both secure and relevant to the needs of end users. This involves eliminating obstacles to innovation for market players, enhancing e-government services, and developing services that are secure and conducive to international trade. It also entails establishing trustworthy services for ASEAN consumers and businesses. Current barriers preventing many businesses and consumers from utilizing digital services need to be addressed. Separate strategies are required for businesses and consumers—the primary users of digital services. For businesses, the emphasis is on enhancing productivity through digital skills, while for consumers, the focus is on enhancing basic digital literacy and affordability to promote widespread adoption of digital services.

By integrating digital activities into existing internationally comparable statistics, policymakers and researchers gain a clearer understanding of the similarities and differences in the production and utilization of digital technologies across ASEAN member states (AMS). This facilitates the evaluation of the economic effectiveness of programs and policies related to digital technologies, allowing countries to compare experiences and potentially learn from one another.

Additionally, continuous monitoring and evaluation of digital initiatives are crucial to ensure their effectiveness and relevance. Establishing a robust framework for assessing the impact of digital policies and programs will enable policymakers to make informed decisions and adjustments as needed. This iterative approach will help ASEAN stay on track towards achieving its digital economy and society goals.

In essence, ASEAN leaders must collaborate to establish regulations that promote the wider deployment of local and national infrastructure, capital, and talent. However, they must ensure that such efforts do not undermine future business opportunities through

excessive intervention. Policymakers must strike a regulatory balance that fosters innovation without disadvantaging local developers or providers. If ASEAN can effectively implement these policies, the region can lead the digital revolution, enhancing competitiveness and improving the lives of its citizens. Prioritizing this opportunity should be a top agenda item for the ASEAN Economic Community (AEC).

5.3 Challenges, Limitations, and Future Research of the Study

It is a fact that there are differences in the development levels of the ten AMS. As a result, some of the latest data that could better define the digital economy are completely unavailable in less developed countries, and one of which is 5G networks. From data collection to data selection stage, this study faces the dilemma of missing data series (less developed countries do not have such data) and missing some countries (if some recent data available only for developing and developed countries are used), and either way, when viewed from a different perspective, can be biased. After reviewed vast of literature, this study chooses to remain all ten member countries, thus omitting some recent data that may provide an in-depth description of the digital economy of some countries. This selection is made upon the consideration to reveal the digital economy performance of all ten member countries of ASEAN without leaving any country out. If certain countries were to be omitted from the analysis, it is no more a complete ASEAN bloc.

For future research, this study would encourage a further and in-depth study that should be carried out and for the research objective to lean more towards to the intra performance of digital economy of a singular country. It can also be a group of countries that are in the same or almost similar level of development, depending on the research goal and analysis factor. It might be able to reveal a closer analysis of the realistic performance of the countries when such analysis is made.

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